Influence of integrated nutrient management on productivity and grain protein content of wheat under sandy soils conditions

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ABSTRACT

A field experiment was conducted at the Experimental Farm of the Faculty of Agriculture, South Valley University at Qena on sandy soil to study the effect of integrated nutrient management (INM) on productivity and grain protein content of wheat. Seven different treatments with three replications each were carried out in the plot in RCB design. The recommended NPK, FYM and biofertilizer (Azotobacter chroococcum) were applied alone and in various combinations among them. The study revealed that the integration of organic manures in combination with biofertilizer and chemical fertilizers was found significant in improving the overall yield attributes, grain yield, straw yield and grain protein content than the sole application of either of these nutrients. Maximum grain yield (2356 kg ha\(^{-1}\)) and straw yield (3614 kg ha\(^{-1}\)) were observed with treatment T6 (half of the recommended NPK + 10 tons FYM + biofertilizer). Like grain and straw yields, the highest grain protein content (11.95%) observed from T6.

Key words: biofertilizers, Azotobacter, FYM, grain yield, grain protein content.

INTRODUCTION

In Egypt, it is well known that the expansion of wheat planting in sandy soils is one of the solutions for curtailing the gap between consumption and production of wheat. However, production of wheat in sandy soils is facing many problems like, low organic matter and poor soil fertility. The high cost of chemical fertilizers and the low purchasing power of most of the farmers restrict its use in proper amounts, hampering crop production. Besides, a substantial amount of the nitrogen is lost through different mechanisms including ammonia volatilisation, denitrification and leaching losses, causing environmental pollution problems (De Datta and Buresh 1989, Choudhury and Kennedy, 2005).

Now, increased attention is being paid to develop an integrated plant nutrition system that maintains and enhances soil productivity through balanced use of different sources of nutrients, including chemical fertilizers, organic fertilizers and biofertilizers. The basic concept, underlying the integrated plant nutrition system, is the adjustment of soil fertility and plant nutrient supply to an optimum level for sustaining desired crop productivity. This might optimize the benefits of all sources of plant nutrients in an integrated manner (Jen-Hshuan, 2006).

Organic manure could help in decreasing wheat mineral fertilizer requirements (Askar et al, 1994 and Shabayek, 1997). Organic fertilization was found to be enhancing growth and productivity of wheat (Atia and Aly, 1998 and Nawab et al, 2006).
El-Bagoury et al., 1998 and Yakout et al., 1998 found that application of organic fertilizer increased grain protein content. Also, Kiani et al., 2005 found that combination of chemical fertilizers, with organic manures, helped in increasing the grain yield of wheat and implied a saving of 50% cost, compared to a system with only mineral fertilization.

Biofertilizers may help in improving crop productivity by increasing the biological nitrogen fixation, the availability and uptake of nutrients and release of natural hormones (Subba-Rao, 1984 and Kannaiyan, 2002). Free-living nitrogen-fixing bacteria eg Azotobacter chroococcum and Azospirillum lipoferum, were found to have not only the ability to fix nitrogen but also the ability to release phytohormones similar to gibberellic acid and indole acetic acid, which could stimulate plant growth, absorption of nutrients, and photosynthesis (Fayez et al., 1985). *Azotobacter* increases the yield of all the agriculture crop plants about 10-12 % (Jaga and Singh 2010). Many workers reported a remarkable stimulation on wheat growth and grain yield with biofertilization (Radwan and Hussein, 1996; Sharief et al, 1998; Elsayed et al 2005 and El-Garhi et al, 2007, Badr et al, 2009, Bahrani et al, 2010). Ozturk et al (2003) reported that grain protein content was increased by the application of chemical nutrients and biofertilizers, compared with untreated plants. Hegab and Abou El-Wafa (2005) showed that the integration between chemical, organic and biofertilizers gave higher grain, straw and biological yields of wheat crop, compared with single application of such fertilizers.

Integrated nutrient management (INM) is a better approach for supplying nutrition to the crop by including organic and inorganic sources of nutrients (Arora, 2008). Keeping the facts in view, the present investigation was planned to find out the appropriate combination of organic and inorganic sources of nutrients and bio-inoculants for improving yield of wheat under sandy soil conditions.

**MATERIALS AND METHODS**

**Experimental site description:**
A field experiment was carried out at the experimental farm of the Faculty of Agriculture, South Valley University at Qena Governorate, Egypt, during 2013/2014 season. It lies at 26°10' N latitude and 32°43' E longitudes with an altitude of 79 m above mean sea level. The soil of the experimental field was sandy having pH 7.88, electrical conductivity 2.52 ds/m, organic carbon 0.49% and available NPK of 186.3, 8.25 and 183.0 ppm, respectively.

**Experimental treatments and design:**
The different treatment combination as follows:
- **T1**- Recommended NPK (190: 70: 120 N, P2O5, K2O kg ha⁻¹).
- **T2**- FYM (20 tons ha⁻¹) alone.
- **T3**- Biofertilizer (*Azotobacter chroococcum*) alone.
- **T4**- Half of the recommended NPK+ 10 tons FYM.
- **T5**- Half of the recommended NPK + biofertilizer.
- **T6**- Half of the recommended NPK + 10 tons FYM + biofertilizer.
- **T7**- Control (without any fertilizers).

For as biofertilizer treatments, the seeds were inoculated by liquid culture of locally isolated strains of *Azotobacter chroococcum* (=10⁹ CFU/ml) which obtained from Biofertilizers Production Unit of Faculty of Agriculture, South Valley University. 1% of carboxy methyl cellulose (CMC) was added to the culture to increase its viscosity to gel form to act as adhesive biostabilizer, the addition of CMC was made just before using. The experiment was carried out in a randomized complete block design (RCBD) with three replications. Experimental unit measured 3.0 m in width and 4 m in length.

**Cultural practices:**
Bread wheat (Giza 168 cv.) was sown on the 15th of November. Whole of phosphorus and potassium were applied basally before sowing in all treatments. Nitrogen fertilizer was applied in three equal doses; the first, during soil preparation, and the second and third after 21 and 63 days from sowing, respectively. The
other cultural practices were carried out as recommended for the crop.

**Measured traits:**
At harvest time, ten fertile stems were taken at random from each plot for measuring spike length, and kernel weight spike$^{-1}$. Also, 1000-kernel weight was estimated for each plot. Meanwhile, grain and straw yields were estimated at plot basis. Grain protein content on dry matter basis was determined by the Kjeldahl method according to AOAC, (1995).

**Statistical analysis:**
The data were analyzed by analysis of variance using MSTAT-C statistical software. The least significant difference (LSD) test at 0.05 levels was used to compare among means of treatments.

**RESULTS AND DISCUSSION**

**Yield attributes:**
The combined use of chemical fertilizer, farmyard manure and biofertilizer plays a significant role on the growth of crop plants. Almost the combined use have significant effect on crop growth as compared to the alone use of chemical fertilizers. Data presented in Table 1 indicated that various studied treatments had a significant on spike length, kernel weight spike$^{-1}$ and 1000-kernel weight. Means in Table 1 shows that greatest values of such traits were from treatment T$_6$ (half of the recommended NPK + 10 tons FYM + biofertilizer). Also, T$_6$ significantly increased spike length, kernel weight spike$^{-1}$ and 1000-kernel weight by 14.7, 14.3 and 12.0 %, respectively, compared to T$_1$ (recommended NPK) and by 62.2, 67.2 and 61.1%, respectively, compared to T$_7$ (control). These findings are in agreement with those of Elsayed et al (2005), El-Garhi et al (2007) and Kler et al (2007).

**Grain and Straw yields:**
Results in Table 2 revealed that application of different levels of fertilizers, organic manures and biofertilizers either alone or in combination significantly increased the grain and straw yields as compared to control. Various treatments of organic and inorganic nutrient combinations had significant effect on grain yield and straw yield. The maximum grain (2356 t ha$^{-1}$) and straw (3614 t ha$^{-1}$) yields were recorded with T$_6$ (half of the recommended NPK+ 10 tons FYM + biofertilizer). T$_6$ increased grain and straw yields by 14.9 and 13.5 % compared with T$_1$ (recommended NPK) and by 85.5 and 76.3% compared with T$_7$ (control). The minimum grain yield (1270 t ha$^{-1}$) and straw yield (2050 t ha$^{-1}$)

**Table 1: Effect of integrated nutrient management on yield attributes of wheat.**

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Spike length (cm)</th>
<th>Kernel weight spike$^{-1}$ (g)</th>
<th>1000-kernel weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T$_1$: Recommended NPK (190:70:120 kg ha$^{-1}$)</td>
<td>12.75</td>
<td>2.722</td>
<td>42.20</td>
</tr>
<tr>
<td>T$_2$: 20 tons FYM (Farm yard manure)</td>
<td>11.55</td>
<td>2.112</td>
<td>37.15</td>
</tr>
<tr>
<td>T$_3$: Biofertilizer (Azotobacter)</td>
<td>11.22</td>
<td>2.033</td>
<td>36.48</td>
</tr>
<tr>
<td>T$_4$: Half of the recommended + 10 tons FYM</td>
<td>12.65</td>
<td>2.711</td>
<td>42.16</td>
</tr>
<tr>
<td>T$_5$: Half of the recommended NPK + biofertilizer</td>
<td>12.35</td>
<td>2.652</td>
<td>41.85</td>
</tr>
<tr>
<td>T$_6$: Half of the recommended NPK + 10 tons FYM + biofertilizer</td>
<td>14.63</td>
<td>3.112</td>
<td>47.25</td>
</tr>
<tr>
<td>T$_7$: Control (without fertilizers)</td>
<td>9.02</td>
<td>1.861</td>
<td>29.33</td>
</tr>
<tr>
<td>F-test</td>
<td>*</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>LSD at 0.05</td>
<td>1.15</td>
<td>0.368</td>
<td>2.35</td>
</tr>
</tbody>
</table>

* and ** significance at 0.05 and 0.01 probability levels, respectively. LSD: Indicates least significant difference.
were recorded with T₇ (Control). Such increase in grain and straw yields, due to application of T₆ might be due to the role of organic fertilizer in enhancing soil biological activity, which improved nutrient mobilization from organic and chemical sources. These results are in harmony with the findings of Atia and Aly (1998) and Nawab et al (2006). Also, Kiani et al (2005) found that combination of mineral fertilizers with organic manures helped in increasing the grain yield of wheat compared to a system with only mineral fertilization. In addition, the biofertilizer with Azotobacter enhancing soil biological activity, which plays a significant role in regulating the dynamics of organic matter decomposition and the availability of plant nutrients and in increasing nitrogen fixer. These results are in concordance with most similar previous studies (Elsayed et al, 2005, El-Garhi et al, 2007, Badr et al, 2009, Bahrani et al, 2010). Meanwhile, in a study on integrated fertilization, Hegab and Abou El-Wafa (2005) showed that the integrated fertilization of chemical, organic and biofertilizers gave higher grain, straw and biological yields of wheat crop, compared with the single application of these fertilizers. There is no significant difference among T₁ (recommended NPK), T₄ (half of the recommended NPK + 10 tons FYM) and T₅ (half of the recommended NPK + biofertilizer) on grain and straw yields. These results suggest saving 50% of chemical fertilizers when using organic or biofertilizers.

The combination of 10 tons ha⁻¹ FYM + half of the recommended NPK was better than 20 tons ha⁻¹ FYM alone for improvement in productivity of wheat which resulted in 372 and 308 kg ha⁻¹ increase in grain yield and straw yield, respectively over FYM application. Kler et al (2007) reported that grain yield, grains per ear and thousand grain weight were significantly higher where 10 t FYM ha⁻¹ with 80% of the recommended mineral fertilizer dose, and with crop residue incorporation/mulching and the recommended fertilizer dose. Also, Azotobacter + half of the recommended NPK resulted in significant increase in productivity of wheat over biofertilizer with Azotobacter alone which resulted in 499 and 667 kg ha⁻¹ increase in grain yield and straw yield, respectively over biofertilizer application.

**Grain protein content (%):**

The results in Table 2 indicated that fertilization treatments had a significant effect on grain protein content. Application of T₆ (half of the recommended NPK + 10 tons FYM +

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<table>
<thead>
<tr>
<th>Treatments</th>
<th>Grain yield (ton ha⁻¹)</th>
<th>Straw yield (ton ha⁻¹)</th>
<th>Grain protein content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T₁: Recommended NPK (190:70:120)</td>
<td>2050</td>
<td>3285</td>
<td>11.89</td>
</tr>
<tr>
<td>T₂: 20 tons FYM (Farm yard manure)</td>
<td>1661</td>
<td>2912</td>
<td>11.72</td>
</tr>
<tr>
<td>T₃: Biofertilizer (Azotobacter)</td>
<td>1506</td>
<td>2490</td>
<td>11.11</td>
</tr>
<tr>
<td>T₄: Half of the recommended + 10 tons FYM</td>
<td>2033</td>
<td>3220</td>
<td>11.78</td>
</tr>
<tr>
<td>T₅: Half of the recommended NPK + biofertilizer</td>
<td>2005</td>
<td>3157</td>
<td>11.66</td>
</tr>
<tr>
<td>T₆: Half of the recommended NPK + 10 tons FYM + biofertilizer</td>
<td>2356</td>
<td>3614</td>
<td>11.95</td>
</tr>
<tr>
<td>T₇: Control (without fertilizers)</td>
<td>1270</td>
<td>2050</td>
<td>11.00</td>
</tr>
<tr>
<td>F-test</td>
<td>**</td>
<td>**</td>
<td>*</td>
</tr>
<tr>
<td><strong>LSD at 0.05</strong></td>
<td>233</td>
<td>335</td>
<td>0.79</td>
</tr>
</tbody>
</table>

* and ** significance at 0.05 and 0.01 probability levels, respectively - LSD: Indicates least significant difference.
biofertilizer) produced grains significantly higher in protein content (11.95%) than other treatments. The minimum amount of grain protein percentage was under the treatment T7 (without any fertilizers) at 11.00%. The results obtained by El-Bagoury et al. (1998) and Yakout et al. (1998) agreed with these results and they concluded that grain protein contents responded to organic matter application. Also, Ram et al. (2014) found that the highest grain protein content in wheat was recorded by green manure + FYM + biofertilizers

CONCLUSION

Generally, it can be concluded that application of half of the recommended NPK+ 10 tons of FYM + biofertilizer on wheat gave the highest values of yield attributes, grain and straw yields. Also, this treatment gave the maximum grain protein percentage. Thus, can saving half the rate of chemical NPK, with high productivity of wheat crop under conditions of this study.

REFERENCES


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