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Comparative Study of Farm Yard Manure and Humic Acid in Integration with Inorganic-N on Wheat (*Triticum aestivum* L.) Growth and Yield

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ABSTRACT

Farmyard manure (FYM) is bulky and humic acid (HA) is compact organic source of plant nutrition. The objective of this study was to investigate the notion that 1 Mg FYM is equal to that of 1 kg HA and to develop an optimized integrated fertilization program. The study was conducted at the research station of Agricultural University Peshawar in Khyber Pakhtoonkwa, Pakistan, in a randomized complete block design with split plot arrangements. FYM (18 Mg ha^{-1}) and HA (18 kg ha^{-1}) were in the main plots, whereas different nitrogen (N) levels (0, 50, 75, 100, 125, and 150 kg ha^{-1}) were in sub-plots. The results indicated a better performance of FYM than HA with significant ($p < 0.05$) differences in many parameters including plant height, leaf area index, chlorophyll content, biological yield, grain yield, and N content of grains. Of the different N levels, the best performance was observed for 100 kg N ha^{-1}. Our present results show that 18 Mg FYM with 100 kg N ha^{-1} may be recommended as good sources for wheat fertilization. However, more research is needed to evaluate the effectiveness of HA as an organic fertilizer and to compare higher HA rates with FYM.

Keywords: Wheat; Fertilization; Farmyard manure; Humic acid; Nitrogen

İnorganik Asit ile Birleştirilmiş Çiftlik Gübresi ve Humik Asidin Buğdayın (*Triticum aestivum* L.) Büyüme ve Verimine Olan Etkisinin Karşılaştırılması

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ÖZET

Bitki beslemede çiftlik gübresi hacimli iken humik asit yoğun organik besin kaynağıdır. Bu çalışmanın amacı; 1 kg humik asidin 1Mg çiftlik gübresine eşit olduğu fikrini araştırmak ve optimum birleşik gübreleme yöntemi geliştirmektir.

Çalışma Pakistan Khyber Pakhtoonkwa Peşaver Tarım Üniversitesi araştırma istasyonunda tesadüf bloklarında bölünmüş parsel deneme deseninde yürütülmüştür. Ana parsellere 18 Mg ha^{-1} çiftlik gübresi ve 18 kg ha^{-1} humik asit uygulanırken alt parsellere 0, 50, 75, 100, 125 ve 150 kg ha^{-1} azot uygulaması yapıldı. Sonuçlar; danelerin azot içeriği, ürün verimi, biyolojik verim, klorofil içeriği, yaprak alan indeksi, bitki yüksekliği dahil olmak üzere en iyi performansın humik asitten ziyade çiftlik gübresinde elde edildiğini göstermiştir ($P<0.05$). Farklı azot seviyelerinde en iyi performans değerleri 100 kg N ha^{-1} oranında elde edilmiştir. Mevcut sonuçlar, buğday gübrelemesinde 100 kg N ha^{-1} ile birlikte 18 Mg ha^{-1} çiftlik gübresi önerilebileceğini göstermiştir. Bununla birlikte humik asidin organik gübre olarak etkinliğinin değerlendirilmesine ve daha yüksek oranlardaki humik asit değerlerinin çiftlik gübresi değerleriyle karşılaştırılmasına ilişkin daha fazla araştırmaya ihtiyaç vardır.

Anahtar Kelimeler: Buğday; Gübreleme; Çiftlik gübresi; Hümik asit; Azot

1. Introduction

Farmyard manure (FYM) and humic acid (HA) are important sources of organic fertilizers, and 1 kg HA are considered to be substituted for 1 metric ton of manure (Tahir et al 2011; Hammad et al 2011; Humintech 2012). Worldwide there are concerns regarding nitrogen (N) loss and ecological contamination from the use of high amounts of N fertilizers (Iqbal et al 2012; Tafteh and Sepaskhah, 2012), whereas low N application is reportedly unsatisfactory because it reduces crop yield (Dadnia et al 2010; Daur et al 2011). With these considerations, the present study was conducted to compare FYM and HA and determine an optimum N level for wheat cultivation under semi-arid climate conditions.

Integration of inorganic N with organic fertilizers has received relatively little attention in the past but has recently been gaining popularity possibly because of the limited amount of N present in organic fertilizers (Delfine et al 2005; Amujoyegbe et al 2007; Abedi et al 2010). There are limited field researches regarding the optimization of nitrogenous chemical fertilizers with organic fertilizers. Abedi (2010) evaluated the effects of different levels of inorganic N (0, 80, 160, and 240 kg ha^{-1}) and organic (0, 30, and 60 Mg municipal solid waste compost ha^{-1}) and reported that the highest wheat grain yield was achieved when the plants were fertilized with 160 kg N ha^{-1} and 30 Mg of compost ha^{-1}. However, many studies such as those of Delfine et al (2005), Yaduvanshi and Sharma (2008), Mandal et al (2009), Dadnia et al (2010). Hammad et al (2011), Tahir et al (2011), Aliasghar and Behzad (2012), Fuertes-Mendizabal et al (2012), and Madani et al (2012) have demonstrated the individual effects of FYM, HA, and N application on wheat, but not their combined effects, this aprroach generated idea for the present study.

The present study compared the effect of 2 important organic fertilizers-FYM and powdered HA-in combination with different inorganic N levels to develop an environmentally and economically feasible fertilization program for wheat. The research findings are based on some important parameters of wheat growth and yield that may provide basis to study effect of these fertilizers at the biochemical level.

2. Material and Methods

Field experiments were conducted on wheat at the Experimental Farm of Agricultural University Peshawar in Khyber Pakhtoonkwa, Pakistan, in 2008–2009 and 2009–2010. To avoid a residual effect, different field was used every year, and composite soil samples were collected from the experimental areas from 0–30 cm depths before sowing to test the soil properties. Soil samples were oven-dried and crushed to pass through a 2 mm sieve. Sand, silt, and clay proportions of the soil were determined using the hydrometer method (Arshad et al 1996). Soil pH was determined using a soil saturation extract, as described by Thomas (1996). Cation exchange capacity (CEC) was measured following method of Page et al (1982). Lime ($CaCO_3$) content was determined by the Scheibler calcimeter method (Allison and Moodie, 1965). Organic matter was determined using the Walkley-Black method (Nelson and Sommers, 1996). Nitrogen content was determined using the Kjeldahl method (Bremner, 1996). Phosphorus (P), potassium (K), copper (Cu), zinc (Zn), iron (Fe), and manganese (Mn) were extracted using Mehlich 1 extracting solution (0.05 M hydrochloric acid [HCl] + 0.0125 M sulfuric acid [H_2SO_4]). Phosphorus (P_2O_5) was determined colorimetrically (Murphy and Riley 1962), and K, Cu, Zn, Fe, and Mn were determined by atomic absorption spectroscopy using Hitachi atomic absorption spectrometer (Model Z-8000). Calcium (Ca) and magnesium (Mg) were extracted using 1 M potassium chloride (KCl). The soil analysis methods used in this study were described by Ryan et al (2001). The results of the selected soil properties are listed in Table 1. The climate of the experimental site was typically subtropical (Figure 1).

In these experiments, 2 organic fertilizers, FYM (18 Mg ha^{-1}) and powdered HA (18 kg ha^{-1}), and 6 N levels (0, 50, 75, 100, 125, and 150 kg N ha^{-1}) from a urea source were evaluated. The fields were planted with a locally manufactured manual running seed drill on October 13, 2008 and October 12, 2009 in 10-row plots, each 5 m long with 30 cm between rows, by using a randomized complete block design with split plot arrangements replicated 4 times. Plots were kept weed-free thereafter by manual weeding. Phosphorus was deficient according to Horneck et al (2007) while following the same researchers' guideline; 40 kg P_2O_5 ha^{-1} from the diammonium phosphate (DAP) was desirable to accomplish crop growth in addition to the organic fertilizer addition. Other cultural practices were consistent with local agronomic practices.

Table 1- Soil properties (0-30 cm) of the experimental site

Çizelge 1- Denemenin yapıldığı alanın 0-30 cm' deki toprak özellikleri

Soil properties (0-30 cm)	*2008*	*2009*
pH	7.2	7.2
CEC (cmol$_c$ kg^{-1})	19.6	21.4
Lime (g 100 g^{-1})	14.0	15.4
EC (dS m^{-1})	2.4	2.6
Sand (g 100 g^{-1})	34.0	34.2
Silt (g 100 g^{-1})	35.8	33.6
Clay (g 100 g^{-1})	30.2	32.2
Soil texture	clay-loam	clay-loam
Organic matter (g 100 g^{-1})	1.94	1.96
N (g 100 g^{-1})	0.11	0.10
P_2O_5 (mg kg^{-1})	12.6	13.2
K (mg kg^{-1})	284	278
Ca (mg kg^{-1})	3264	3198
Mg (mg kg^{-1})	182	186
Fe (mg kg^{-1})	54.2	56.1
Cu(mg kg^{-1})	1.50	1.42
Zn (mg kg^{-1})	2.11	2.14
Mn (mg kg^{-1})	8.64	8.70

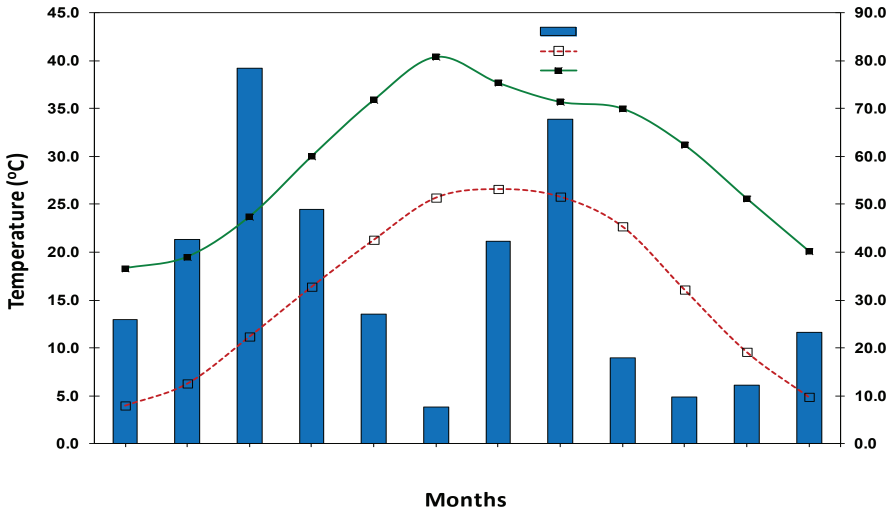

Figure 1- Climatic conditions of the research site, average temperatures (left ordinat) and rainfall throughtout the year (right ordinat)

Şekil 1- Araştırmanın yapıldığı bölgenin ortalama sıcaklığı (sol Y ekseni) ve yağış durumu(sağ Y ekseni)

2.1. Procedures for data recording

Plant height (from the soil surface to the tip of the spike) was recorded from an average of 10 individual, randomly selected plants at time of anthesis in each subplot. Leaf area index (LAI) was determined using a SunScan canopy analysis system (Delta-T Devices Ltd., Cambridge, UK). Three measurements were taken randomly between different rows in each plot, and the average was then calculated. Leaf chlorophyll content was measured using SPAD-502 (Minolta Co. Ltd., Osaka, Japan). A total of 15 intact and fully expanded leaves were randomly selected in each subplot, and the SPAD reading of each was taken from the leaf center. The average of the 15 individual SPAD measurements was calculated. Grain yield was recorded in 6 central rows of each subplot and then converted into kg ha^{-1}. Biological yield data were obtained for 6 central rows of each subplot at maturity and then converted into kg ha^{-1}. Nitrogen content in the grains was determined using the Kjeldahl method (Bremner, 1996). Data were analyzed statistically by using MSTATC software for analysis of variance, and means were compared using the least significant differences (LSD) test (Russell, 1986).

3. Results and Discussion

3.1. Plant growth and development

Plant height and LAI were significantly ($p < 0.05$) affected by the organic fertilizers FYM and HA as well as N levels (Figure 2 and Figure 3). The interaction between the organic fertilizers and N levels was non-significant for these parameters. Our results showed that integration of FYM with 150 kg N ha^{-1} resulted in the production of tall plants (120 cm); this finding was statistically similar to that obtained by integration of FYM with 100 and 125 kg N ha^{-1} treatments. The maximum LAI of 2.7 was obtained for plants that received FYM integrated with 150 kg N ha^{-1}; this was statistically in accordance with the LAI obtained for FYM integrated with 100 kg N ha^{-1} and 125 kg N ha^{-1}. Similar results were reported by Amujoyegbe et al (2007) and Iqbal et al (2012), who observed that increasing N fertilizer up to a certain level considerably influenced plant height and leaf area. The probable reason for this is that a higher N supply or the optimum fertilizers played an essential role in enhanced vegetative growth, as reported by Fuertes-Mendizabal (2012), Madani et al (2012), and Montazar and Behzad (2012).

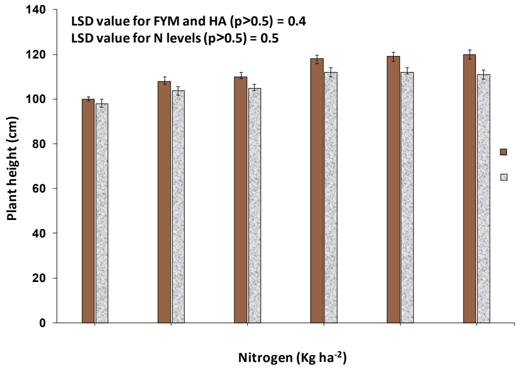

Figure 2- Plant height of wheat as affected by organic fertilizers (FYM and HA) and nitrogen levels. Data series represent the two years mean ±S.D.(error bars)

Şekil 2- Organik gübreler (çiftlik gübresi ve hümik asit) ve azot seviyelerinden etkilenen buğday bitki yüksekliği. Veriler 2 yılın ortalamasıdır

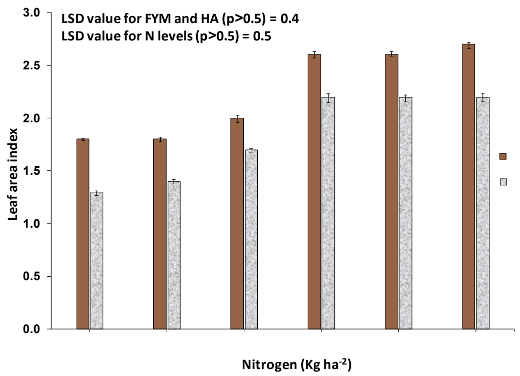

Figure 3- Leaf Area Index of wheat as affected by organic fertilizers (FYM and HA) and nitrogen levels. Data series represent the two years mean ±S.D.(error bars)

Şekil 3- Organik gübreler (çiftlik gübresi ve hümik asit) ve azot seviyelerinden etkilenen buğday bitki yaprak alan indeksi. Veriler 2 yılın ortalamasıdır

The SPAD chlorophyll reading was significantly ($p > 0.05$) affected by N levels but was non-significantly affected by FYM and HA (Figure 4). There was no interaction between organic fertilizers and N levels for the SPAD chlorophyll reading. The SPAD chlorophyll measurement was maximal for 100 kg N ha^{-1}, which was similar to the SPAD chlorophyll measurement for 125 kg N ha^{-1} and higher levels of N. Our chlorophyll content result is in accordance to that obtained by Amujoyegbe et al (2007) and Islam et al (2009), who reported that the lowest chlorophyll content occurred in the control plot and it increased with the N level. Delfine et al (2005) support our results as with them no effect of organic fertilizers was observed on chlorophyll and photosynthesis.

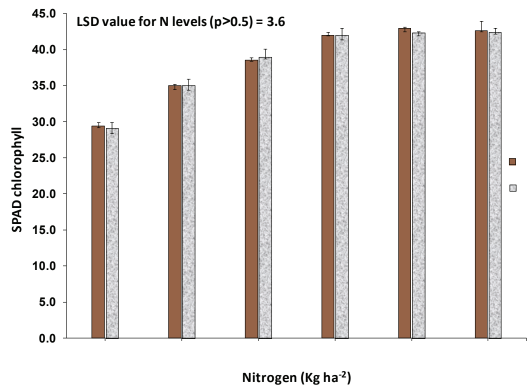

Figure 4- SPAD chlorophyll of wheat as affected by organic fertilizers (FYM and HA) and nitrogen levels. Data series represent the two years mean ±S.D.(error bars)

Şekil 4- Organik gübreler (çiftlik gübresi ve hümik asit) ve azot seviyelerinden etkilenen buğday bitki SPAD klorofil değerleri. Veriler 2 yılın ortalamasıdır.

3.2. Yield and yield components

Significant ($p < 0.05$) differences between the organic fertilizers, FYM and HA, and various N levels were observed with respect to biological yield (Figure 5), grain yield (Figure 6), and N content of grains (Figure 7); however, no interaction was observed between the source organic fertilizers, and

N levels (Figures 5, 6 and 7). Biological yield (9867 kg ha^{-1}) was maximal for FYM with 150 kg N ha^{-1} treatment but this was statistically parallel to FYM with 100 kg N ha^{-1} and 125 kg N ha^{-1}. Grain yield which is the economic yield of wheat was highest (3392 kg ha^{-1}) for FYM with 100 kg N ha^{-1}. Despite grain N content (2.6%) was highest for FYM and 150 kg N ha^{-1} combination, this was statistically similar to FYM with 100 kg N ha^{-1} and 125 kg N ha^{-1} treatments. Our results are supported by Yaduvanshi et al (2008), Islam et al (2009), Mandal et al (2009), Abedi et al (2010), Dadnia et al (2010), Hammad et al (2011), Iqbal et al (2012), and Madani et al (2012) who have observed similar increases in biological yield, grain yield, and N content of crops after the addition of N or a combination of N with manure. Furthermore, the results achieved with HA are parallel to those of Delfine et al (2005), who reported that HA is a limited source of plant nutritions for plant growth, grain yield, and quality, but contrasting to Tahir et al (2011), who have reported significant increase in growth (plant height and shoot weight) and N uptake of wheat with HA.

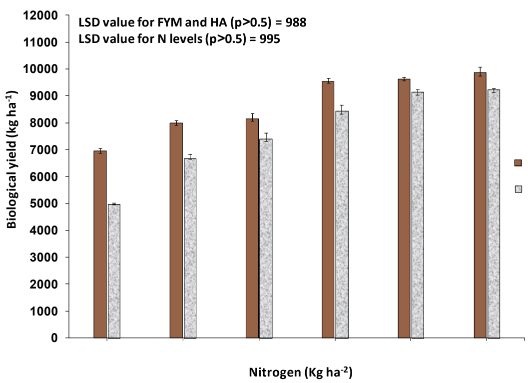

Figure 5- Biological yield of wheat as affected by organic fertilizers (FYM and HA) and nitrogen levels. Data series represent the two years mean ±S.D.(error bars)

Şekil 5- Organik gübreler (çiftlik gübresi ve hümik asit) ve azot seviyelerinden etkilenen buğday biyolojik verimi. Veriler 2 yılın ortalamasıdır

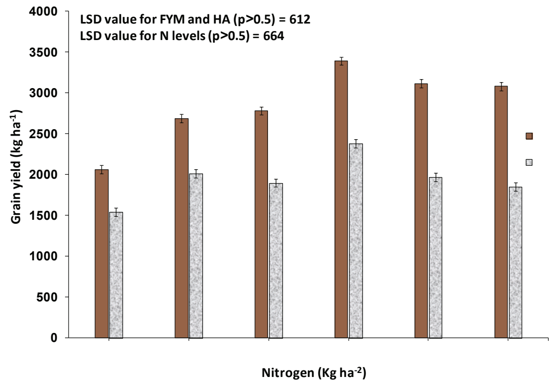

Figure 6- Grain yield of wheat as affected by organic fertilizers (FYM and HA) and nitrogen levels. Data series represent the two years mean ±S.D.(error bars)

Şekil 6- Organik gübreler (çiftlik gübresi ve hümik asit) ve azot seviyelerinden etkilenen buğday dane verimi. Veriler 2 yılın ortalamasıdır

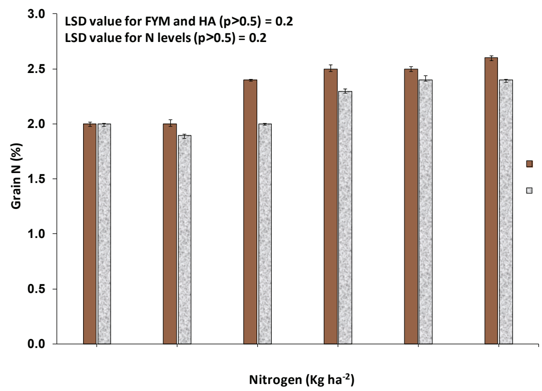

Figure 7- Grain nitrogen content of wheat as affected by organic fertilizers (FYM and HA) and nitrogen levels. Data series represent the two years mean ±S.D.(error bars)

Şekil 7- Organik gübreler (çiftlik gübresi ve hümik asit) ve azot seviyelerinden etkilenen buğday bitki azot oranı. Veriler 2 yılın ortalamasıdır

4. Conclusions

The results of this study indicated that 18 kg of HA not increased wheat growth and yield as 18 Mg of FYM did. However, comparisons of higher levels of HA are suggested for evaluation in future research to further explore this idea. Moreover, on the basis of various parameters especially grain yield that is the economic part of wheat, 100 kg N ha^{-1} combined with either FYM or HA was found to be optimal chemical N fertilization rate. Consequently, we recommend an application of 100 kg N ha^{-1} with 18 Mg FYM for wheat production with similar yield and in similar environmental conditions.

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