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Influence of Nitrogen Fertilization Rates and Residual Effect of Organic Manure Rates on the Growth and Yield of Wheat (*Triticum aestivum* L.)

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ABSTRACT. A two-year field experiment was initiated on loamy sand soil in 1992-1993 and 1993-1994 to study the effect of synthetic nitrogen fertilizer and residual effect of organic manure on growth, yield and yield components of wheat cv. Yecora rojo. Nitrogen fertilization increased both yield and plant height. Yields increased from 1.34 to 5.54 ton ha^{-1} by increasing N from 0 to 200 Kg ha^{-1}. The increase in yield was attributed to increased number of spikes m^{-2}, number of grains $spike^{-1}$ and 1000-grain weight. Yields were also increased from 3.20 to 3.66 ton ha^{-1} by increasing organic manure from 0 to 50 ton ha^{-1}. Plant height and flag leaf area increased from 8.43 to 72.16 cm and from 10.23 to 23.64 cm^2 due to increasing N level from 0 to 200 Kg ha^{-1}. Plants receiving 200 kg N ha^{-1} with 50 ton ha^{-1} organic manure produced plants with more spikes, number of grains, biological yield, grain and straw yield. However, the crop index was higher in plots receiving 200 Kg N ha^{-1} without organic manure residues. The rate of increase for plant height, number of spikes m^{-2}, number of grains $spike^{-1}$, biological yield and grain and straw yield was higher under low than high nitrogen application rates.

Maximizing wheat grain yield per unit area is considered as one of the important goals under Saudi conditions. Plant nitrogen use efficiency is dependent on several factors, including application time, rate of applied nitrogen, soil moisture content and other climatic-related variable (Purcell 1990). Nitrogen, which is normally a key factor in achieving optimum grain yields, is the most limiting nutrient in Saudi irrigated wheat systems and grain yield is closely correlated with plant nitrogen accumulation. Several investigators stated an increase in wheat yield and its attributes due to increased nitrogen levels (Mashhadi *et al.* 1989, Ahmed 1994). Daniels and Scott (1991) reported a 3 years' mean grain yield of wheat of 3.17 tons ha^{-1} with 170 Kg N ha^{-1}. Similarly, Eck (1988) stated that a rate of 140 Kg N ha^{-1} rather than 210 Kg N ha^{-1} was sufficient to obtain maximum grain yield of a non-stressed crop. This study showed that under well water irrigation, application at a rate of 150-225 Kg N ha^{-1} produced a grain yield between 4.49 and 4.45 tons ha^{-1} and biomass between 12.56 to 13.50 tons ha^{-1}. Grain yield of wheat was 1.70 and 2.50 tons ha^{-1} with 0 and 120 Kg N ha^{-1}, respectively, at moderate soil moisture and 1.32 and 1.64 tons ha^{-1} with high soil moisture (Gauer *et al.* 1992).

Farmers are looking for less expensive chemical inputs for crop production (Harwood 1984). For example, legumes in crop rotations can substitute for synthetic fertilizer by supplying nitrogen. Manures, sludge, composted materials, and rock phosphate can also serve as nutrient sources. Interest in partial substitution of organic nitrogen sources for commercially produced inorganic fertilizer-N is justified by the magnitude of present and future nitrogen requirements of wheat. Manure can increase soil productivity when returned to the soil in reasonable amounts (Parr *et al.* 1984). Low rates of manure applications can improve soil physical properties (Cook 1984) and soil water-holding capacity (Sahs and Lesoing 1985). Research comparing alternative and conventional farming systems is needed because, in the future, synthetic fertilizers may not be readily available or economical. El-Sherif *et al.* (1969) concluded that farmyard manure increased wheat nutrient uptake.

Shahawi and Amer (1984) and Shahawi (1986) concluded that applying soil conditioners of narrow (Berseem) or wide (wheat straw) C/N ratios with nitrogen fertilizers enhanced ammonification, nitrification, immobilization of mineral nitrogen. The practice also alleviated the adverse effect of salinity on nitrogen transformation in soil, increased soil organic carbon, improved nitrogen fixation and improved C/N ratio of the soil.

The present study was conducted to measure the effects of synthetic nitrogen fertilizer and residual effect of organic manure on growth and productivity of the hard winter wheat cultivar "Yecora rojo", which is a high-yielding cultivar with high biomass production. Lodging resistance also appeared to be an important trait of this cultivar.

Materials and Methods

Field studies were initiated in the winter season of 1992 on sandy loam soil at the Research Station, King Faisal University, located on the main Hofuf-Qatar Highway in Al-Hassa, Saudi Arabia and continued on the same plots during winter season 1993. The initial soil data (0 to 50 cm) for the site is presented in Table 1.

Table 1. Physical and chemical properties of soil in the experimental site

Studied character	**Soil profile (depth, cm)**		**Soil critical value for wheat (Cottonie 1980)**
	0 - 25	**25 - 50**	
Physical Properties			
Sand %	74.6	39.2	
Silt %	25.0	49.7	
Clay %	0.4	11.1	
Soil Type	Loamy sand	Loam	
Chemical Properties			
$CaCO_3$ %	21.54	23.31	
EC (mmhos/cm)	2.722	2.750	
pH	7.62	7.58	
OM (%)	0.295	0.111	0.52 - 9.54
Available K (ppm)	256	239	175 - 300
Available Cu (ppm)	0.18	0.10	0.5
Mn (ppm)	1.61	1.61	2.2
Fe (ppm)	2.11	2.51	4.5
P (ppm)	7.6	4.5	5-9
Total Nitrogen (%)	0.026	0.125	< 0.52 - 0.55
Cation Exchange capacity (meq/lit)	14.06		

The above measurements were determined according to Richards 1968.

The experimental design was a randomized complete block having a split-plot arrangement of treatments with three replications. Organic manure (cow feed lot manure) rates of 0 to 50 tons ha^{-1} presented the main plots, and synthetic nitrogen fertilizer (urea) rates of 0, 50, 100, 150 and 200 Kg N ha^{-1} presented the sub-plots.

Fertilizer nitrogen treatments were applied in two equal doses after 30 and 45 days from planting. Wheat (*Triticum aestivum* L. cv. Yecora rojo) was planted on November 27th and 8th in 1992 and 1993, respectively. The seeding rate was 120 Kg ha^{-1} with a row to row spacing of 20 cm having 2 x 4 m^2 plots. The crop received its first irrigation just after planting. Subsequent irrigations were applied at weekly intervals throughout the growing season until two weeks before harvesting.

At seeding time each year, P as superphosphate was placed near the seeds at a rate of 50 Kg P_2,O_2 ha^{-1} yr^{-1}. The residual effect of organic manure applied to the previous crop at the rate of 0 and 50 tons ha^{-1} was considered, because no crop was cultivated after harvesting the first crop.

Plant height, flag leaf area, number of spikes m^{-2}, number of grains $spike^{-1}$, biological yield, grain yeild and straw yield were recorded. All these measurements were taken by harvesting 0.25 m^2 area from the center of each sub-plot. Harvesting dates were late May and early June for 1992/93 and 1993/94, respectively. Harvest index (HI) was calcualted as the ratio of grain yield and biological yield (Mercedes *et al.* 1993). Crop index (CI) was calculated as the ratio of grain yield and straw yield as reported by Ahmed (1994). Flag leaf area was measured with a leaf-area-meter (Model Delta-T-Devicer, Hitachi Manufacturer, Taiwan). Soil samples were analyzed according to Richards (1968).

The two-years combined data was statistically analyzed using the General Linear Model (SAS 1987) and the treatment means were separated using Duncan's New Multiple Range Test (Snedecor and Cochran 1967).

Results and Discussion

Analysis of variance showed that the measured parameters did not differ with years but showed significant effects of organic manure, nitrogen treatments and manure-by-nitrogen interactions for all traits on both years.

Effect of Nitrogen Application:

Plant Height: Plant height responded significantly to N fertilization in both years, when the greatest plant height was found at the highest N rate. There was a significant difference in plant height among nitrogen treatments at all organic manure levels (Table 2). Plant height ranged between 48.43 cm (0 Kg N ha^{-1}) and 72.16 cm (200 Kg N ha^{-1}). Taller plants resulted from each 50 Kg N ha^{-1} increment (Table 2). The data indicate that, in the field, N often stimulated increases in plant height. As reported by Clarke *et al.* 1990, plant height was directly related to N

Table 2. Effect of cowdung residues and nitrogen fertilizer rates on wheat growth, yield and yield components

Treatments	Plant height (cm)	Flag leaf area (cm^{-2})	Spikes m^2 (No.)	Grain $spike^{-1}$ (No.)	1000 Grain weight (g)	Biological yield (ton ha^{-1})	Grain yield (ton ha^{-1})	Straw yield (ton ha^{-1})	Harvest index	Crop index
Nitrogen rates (Kg ha^{-1})										
0.0	48.43e	10.23d	177.06e	20.30e	35.38c	4.54e	1.34e	3.20e	0.30c	0.48b
50	64.02d	19.62c	239.56d	27.88d	36.36c	7.37d	2.20d	5.14d	0.32bc	0.49b
100	66.91c	18.27b	317.56c	35.19c	41.34b	10.91c	3.55c	7.30c	0.36ab	0.55ab
150	69.93b	22.83a	354.75b	39.69b	44.83a	12.83b	4.45b	8.29b	0.38a	0.56ab
200	72.16a	23.64a	428.94a	41.69a	46.47a	14.63a	5.54a	9.16a	0.36ab	0.59a
Organic manure residue (ton ha^{-1})										
0	63.15b	16.58b	295.75b	32.85b	39.66b	9.43b	3.20b	6.23b	0.34a	0.53a
50	65.6a	19.25a	315.40a	33.05a	42.09a	10.68a	3.66a	7.02a	0.35a	0.54a

Means followed by similar letters within each column for each treatment are not significantly different using Duncan's multiple range test (P = 0.05).

level.

Flag Leaf Area: Leaf area values were significantly increased by applied N on all treatments (Table 2). Measured flag leaf area values ranged between 10.23 (control) to 23.64 cm^2 (200 Kg N ha^{-1}). In fact, flag leaf area is a function of complex combination of factors because it is influenced by environmental conditions and nutrient availability (Slavick 1966). There were significant increases in flag leaf area with increases in nitrogen application rates. Leaf area increased with the 50 Kg N ha^{-1} increment upto 150 Kg N ha^{-1}.

Grain Yield and Yield Components:

Grain Yield: Treatments and all associated contrasts significantly influened grain yield (Table 2). The nitrogen fertilizer treatments significantly increased grain yield as compared with the control plots which ranged between 1.34 tons ha^{-1} (control) and 5.54 tons ha^{-1} (200 Kg N ha^{-1}). This could be due to significantly more and heavier spikes (Table 2). Higher yield was associated with more spikes m^{-2} and a greater grain weight. Similar results were reported by several investigators (Legg and Melsinger 1982, Baethgen and Alley 1989).

Number of Spikes m^{-2}: Treatments differences in the number of spikes per square meter were observed during years of study. Spike per square meter for Yecora rojo were significantly higher with increased nitrogen level with or without the presence of residual manure (Table 2 and 3). Nitrogen fertilizer addition significantly increased spike in m^{-2}. These findings were in line with those reported by Caldwell and Starratt (1987). The range of spikes m^{-2} was from 177.06 (control) to 428.94 (200 Kg N ha^{-1}). The increase was significant with increasing rates of nitrogen application.

Grains Per Spike: Number of grains per spike varied among treatments. In the two years of study, increasing levels of N fertilizer significantly increased grains $spikes^{-1}$ (Table 2 and 3). Similar results were reported by Caldwell and Starratt (1987). The number of grains $spike^{-1}$ varied between 20.30 (control) to 41.69 (200 Kg N ha^{-1}).

1000 Grain Weights: In general, the 1000-grain weights were significantly increased by N fertilizer addition (Table 2), but there were no differences in the interaction response. The weight per 1000 grains ranged between 35.58 g (control) to 46.47 g (200 Kg N ha^{-1}) in different nitrogen treatments.There was a significant increase in grain weight with increase in nitrogen application upto 150 Kg N ha^{-1}, with no significant increase ($P > 0.05$) thereafter.

Table 3. Effect of the interaction between nitrogen fertilizer rates and cowdung residues on wheat growth, yield and its attributes (combined analysis of 1992/1993 and 1993/1994 seasons)

	Nitrogen rates (Kg N ha^{-1})				
	0.0	**50**	**100**	**150**	**200**
Organic manure residue (ton ha^{-1})					
			Plant height (cm)		
0.0	47.99Aa	61.84Bb	66.06Ac	68.30Bc	67.56Bc
50	48.88Aa	66.20Ab	67.76Ab	71.55Ac	73.66Ac
			Number of spikes/m^2		
0.0	174.5Aa	228.0Ab	309.75Ac	340.88 Ac	405.50Bc
50	179.50Aa	251.13Ab	325.38Ac	368.63Ad	452.38Ac
			Number of grains/spikes		
0.0	21.0Aa	28.25Ab	34.88Ac	39.215Ad	40.88Ad
50	19.63Aa	27.50Ab	35.50Ac	40.13Ad	42.50Ad
			Biological yield (ton/ha)		
0.0	4.425Aa	7.00Ab	10.188Bc	11.913Bd	13.625Be
50	4.650Aa	7.738Ab	11.638Ac	13.750Ad	15.625Ae
			Grain yield (ton/ha)		
0.0	1.089Ba	1.989Bb	3.473Ac	4.299Bd	5.150Be
50	1.584Aa	2.416Ab	3.623Ac	4.594Ad	5.569Ae
			Straw yield (ton/ha)		
0.0	3.358Aa	5.011Aab	6.596Abc	7.486Acd	8.456Ad
50	3.066Aa	5.260Ab	8.009Ac	9.091Acd	9.868Ad
			Crop Index		
0.0	0.380Aa	0.449Aa	0.600Bb	0.608Ab	0.615Ab
50	0.599Aa	0.511Aa	0.496Aa	0.516Ba	0.573Aa

Differences in wheat grain yield and yield components due to management can occur as has been reported by Major *et al.* (1992). In this experiment, Yecora rojo was highly responsive to N addition. Yecora rojo yielded relatively well under high levels of added nitrogen fertilizer and low moisture availability typical of wheat production in other Saudi regions. In general, Yecora rojo had the greatest reponse to N addition in the presence of organic manure residue. These results confirm those of Caldwell and Starratt (1987) who found that wheat cultivars responded well to management inputs.

These data indicated that Yecora rojo gave a maximum yield when it received 200 Kg N ha^{-1} (Tables 2 and 3). As relatively high grain yields were reached, it seems that there was no N limitation at 200 Kg N ha^{-1} (Nuttal and Malhi 1991). Organic manure x nitrogen fertility interactions seen here (Table 3) concur with those of Cassman *et al.* (1992) but contradicted those of Wang and Below (1992).

Grain yield is determined by its components, thus grain yield response to the treatments may be attributed to the response of its components. The observed improvements in yield were largely due to increase in spikes m^{-2} rather than grain $spike^{-1}$ or grain weight (Table 2). Major *et al.* (1992) observed similar fertility responses by wheat. The average grain weight and grain $spike^{-1}$ at 150 Kg N ha^{-1} level were great, but this did not completely compensate for the lower average number of spikes m^{-2}. As a result, grain yield at the 150 Kg N ha^{-1} level was lower than at the 200 Kg ha^{-1} level.

Biological Yield: The biological yield ranged between 4.54 tons ha^{-1} (control) to 14.63 tons ha^{-1} (200 Kg N ha^{-1}) for different nitrogen rates. The yield increased significantly with increase in nitrogen rates.

Straw Yield: The data in Table 2 show that straw yields increased with increasing increments of N through 200 Kg N ha^{-1} in both years of study. The straw yield varied between 3.20 tons ha^{-1} (control) to 9.16 tons ha^{-1} (200 Kg N ha^{-1}) in different nitrogen treatments. In general, Yecora rojo had the highest straw yield at high N levels while the control had the lowest. The increase in straw yield was probably because N fertilizer improved the survival of main stems and tillers.

Harvest Index (HI): Inspection of the effects of nitrogen treatments on HI shows that compared to those on the control treatment, HI was decreased on treatment 200 Kg N ha^{-1} and increased on the other treatments. These differences from the control resulted in significant differences in HI between treatments. HI of the 200 Kg N ha^{-1} was not different from that of the 100 Kg N ha^{-1} or of the 50 Kg N

ha^{-1}. The highest N level reduced HI by reducing grain yield as compared to vegetative growth. The harvest index ranged between 0.30 (control) to 0.38 (150 Kg N ha^{-1}) for different nitrogen treatments. The HI increased significantly with increase in nitrogen application up to 100 Kg N ha^{-1} with no significant difference thereafter.

Crop Index (CI): Wheat gave greater yields of straw because favourable weather during the vegetative phase allowed vigorous growth while unfavourable weather during the reproductive phase reduced grain setting and development, thus resulting in differences in grain: straw ratio *i.e.* crop index. CI of wheat increased linearly with N additions (Table 2). The crop index ranged between 0.48 (control) to 0.59 (200 Kg N ha^{-1}). However, CI was not significantly different from the control until 150 Kg N ha^{-1} rate, while there were no significant differences ($P > 0.05$) between 100, 150 and 200 Kg N ha^{-1}. Similar results have been reported by Campbell *et al.* (1977).

Effect of Organic Manure Residue:

The analysis of variance indicated that all measured plant growth parameters were significantly higher for plots receiving 50 tons ha^{-1} organic matter in the previous crop than the control treatments (Table 2). However, harvest index (HI) and crop index (CI) were not significantly different between the two treatments. This shows that the residual effect of organic matter applied to the previous crop remained effective and improved the wheat yield, but did not influence harvest and crop indices. This could be due to the improvement in physico-chemical properties of the soils (El-Sherif *et al.* 1969, Patel and Patel 1992), increase in soil microbial population and its positive role in mobilization of nitrogen transformation in soil for easy availability to plants (Shahawi and Amer 1984, Shahawi 1986). Similar findings were reported by El-Haris *et al.* (1983) who stated that nitrogen fertilizer retained in stalk, leaves and roots as well as mobilized by soil microbial augments soil organic nitrogen and thus providing a residual nitrogen source for a subsequent crop.

Effect of the Nitrogen Rates X Organic Manure Residuals:

Data of Table (3) indicated significant effects of organic manure-by-nitrogen interactions for wheat studied parameters. Whereas, the insignificant interactions were excluded from the result.

Plant height showed increases with increase in nitrogen application which hold true for both cases with and without organic manure residues. Taller plants were obtained at application of 200 Kg N ha^{-1} when grown with organic manure residues. The rate of increase was higher at the nitrogen rate of 50 Kg N ha^{-1} under organic manure residues as compared to the other higher nitrogen application rates. This showed that organic manure residues coupled with high nitrogen rates stimulated plant growth and that increased N rate application would not be cost beneficial. A similar trend was obtained by Gangwar and Niranjan (1991) who concluded that application of farmyard manure with low doses of nitrogen was beneficial for growth and yield of pearl millet.

A similar trend was obtained for number of spikes per m^{-2}, biological yield and grain yield with the highest output at the application of 200 Kg N ha^{-1} under organic manure residues. Similar results were obtained by El-Haris *et al.* (1983), Ebelhar *et al.* (1984), Roder *et al.* (1989), Gangwar and Niranjan (1991) and Niranjan and Arya (1992).

Crop index showed a different response. Increased nitrogen fertilizer rates caused an increase in the crop index without residual effects of organic manure. Under the organic manure residues, the crop index showed a decrease with increase in nitrogen rates. This was due mainly to less rate of increase in grain yield under the organic manure residues as compared with that which was not exposed to the organic manure residues; as well as the opposite trend obtained in straw yield which is reflected mainly on the crop index.

Conclusion

Applying nitrogen fertilizer appeared to have higher effect on yield than organic manure residues. Significant grain yield increases, however, were obtained with split applications of nitrogen fertilizer in the presence of organic manure residues.

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تأثير النيتروجين والأثر المتبقي للمادة العضوية على النمو وإنتاجة محصول القمح

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قسم المحاصيل والمراعي - كلية العلوم الزراعية والأغذية - جامعة الملك فيصل
ص .ب (٤٢٠) - الأحساء ٣١٩٨٢ - المملكة العربية السعودية

أجريت تجربة حقلية لمدة عامين (١٩٩٢/ ١٩٩٣م - ١٩٩٣/ ١٩٩٤م) لدراسة تأثير النيتروجين (صفر ، ٥٠ ، ١٠٠ ، ١٥٠ ، ٢٠٠ كجم/ هكتار) والأثر المتبقي للمادة العضوية (صفر و ٥٠ طن/ هكتار) على نمو وإنتاجية محصول القمح (صنف يوكوروجو) وقد أظهرت النتائج زيادة معنوية في محصول القمح لطول النبات ومساحة الورقة العلم وعدد السنابل في المتر المربع وعدد الحبوب في السنبلة ووزن الألف حبة والمحصول البيولوجي وانتاجية الحبوب وانتاجية القش ومعامل الحصاد ومعامل المحصول مع ارتفاع معدل النيتروجين المضاف . وتعزى الزيادة في انتاجية الحبوب للزيادة في عدد السنابل في المتر المربع وعدد الحبوب في السنبلة ووزن الألف حبة .

لقد ارتفعت انتاجية الحبوب من ٣٤ ,١ إلى ٥٤ ,٥ طن/ هكتار بارتفاع معدل النيتروجين من صفر إلى ٢٠٠ كجم/ هكتار كما ان الانتاجية قد ارتفعت من ٢٠ ,٣ إلى ٦٦ ,٣ طن/ هكتار بزيادة المادة العضوية من صفر إلى ٥٠ طن/ هكتار . وكانت الزيادة في طول النبات ومساحة الورقة العلم من ٤٣ ,٨ إلى ١٦ ,٧٢ سم^{٢} ومن ٢٣ ,١٠ إلى ٦٤ ,٢٣ سم^{٢} على التوالي لزيادة

مستويات النيتروجين من صفر إلى ٢٠٠ كجم/ هكتار ولقد أظهرت النتائج ان الأثر المتبقي من المادة العضوية كان له تأثير إيجابي على الصفات تحت الدراسة بينما كان تأثيره على الاختلافات في معامل الحصاد ومعامل المحصول غير معنوي .

أعطت النباتات المعاملة بـ ٢٠٠ كجم نيتروجين والمنزرعة في القطع التجريبية الحاوية على الأثر المتبقي لإضافة ٥٠ طن/ هكتار مادة عضوية ، زيادة ملحوظة في عدد السنابل ، عدد الحبوب ، المحصول الكلي ومحصول الحبوب مع القش . ولقد كان هناك ارتفاع في دليل المحصول للنباتات المعاملة بـ ٢٠٠ كجم نيتروجين/ هكتار والمنزرعة في القطع التجريبية الخالية من الأثر المتبقي من المادة العضوية . معدل الزيادة لطول النبات ، عدد الحبوب في السنبلة للمتر المربع ، المحصول الكلي ومحصول الحبوب مع القش كان اكثر ارتفاعاً في النباتات تحت المعاملة المنخفضة من النيتروجين من النباتات المعاملة بالمعدلات النيتروجينية العالية .