Annals of Agric. Sci., Moshtohor **ISSN 1110-0419**
Vol. 54(1) (2016), 1– 14 **http://annagricmoshj.com**

Growth, yield and yield components of wheat as affected by crop sequences, seeding rates and nitrogen fertilizer levels

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Abstract

Two field experiments were carried out in Kafr El-Hamam Agriculture Research Station, Sharkia Governorates, ARC, during 2013/2014 and 2014/2015 seasons to study the effect of five crop sequences (maize/wheat (CS1), intercropping potatoes with maize/wheat (CS2), maize/fahl berseem/wheat (CS3), maize/peas/wheat (CS4), maize/fodder maize/wheat (CS5)) and four combination treatments between seeding rates and nitrogen fertilizer levels were as follows 50 kg seeds+60 kg N/fed (SN1), 50 kg seeds+75 kg N/fed (SN2), 60 kg seeds+60 kg N/fed (SN3), 60 kg seeds+75 kg N /fed (SN4) on growth, yield and its components of wheat (cv. Sakha 94). The treatments were arranged in a split plot design with three replications. The main plots were occupied by crop sequences and seeding rates with N fertilizer levels were assigned to the sup plots. The results revealed that:

Crop sequences had significant effect on plant height, number of tillers and spikes/m^2, spike length, weight of spike and grains/spike, 1000-grain weight, grain yield, cereal units, total income and total net income of wheat in both seasons as well as straw yield/fed in 1st season only. Legume as preceding crops for wheat gave significantly higher grain yield compared with fodder maize. Whereas, the highest grain yield and net income after fahl berseem, (2.959, 2.980 ton/fed and 5422, 5414 L.E/fed), was at par with grain yield and net income obtained after peas, being (2.886 and 2.939 ton/fed as well as 5191 and 5071 L.E/fed), with an ignored differences in the 1st and 2nd seasons, respectively.

Increasing seeding rates from 50 to 60 kg/fed caused a significant increase in number of tillers and spikes/m^2, grain and straw yields/fed. On the other hand, increasing seeding rates caused a reduction in spike length, number of spikelets/spike, weight of spike and grains/spike as well as 1000-grain weight.

All characters gradually increased by increasing N fertilizer levels from 60 to 75 kg N/fed. Maximum grain yield was 2.801 and 2.888 ton/fed obtained from SN4 (60 kg seeds+75 kg N /fed) followed by SN2 (50 kg seeds+75 kg N/fed) being, 2.757 and 2.825 ton/fed in 1st and 2nd seasons, respectively. Similarly, the highest cereal units, total income and net income were detected with SN4 (60 kg seeds+75 kg N /fed) followed by SN2 (50 kg seeds+75 kg N/fed). It is worth to noting that under the same level of N fertilizer differences among seeding rates did not reach level of significance.

The interaction effect of crop sequences and seeding rates and N fertilizer levels showed significant differences in plant height, spike length, spike weight and 1000-grain weight.

Multiple cropping had significantly increased total cereal units, net incomes, land use efficiency (multiple cropping index (MCI) and cultivated land utilization index (CLUI)).

Keywords: wheat, crop sequence, seeding rates, nitrogen fertilizer levels, cereal units, total net income, land use efficiency.

Introduction

Wheat (*Triticumaestivum* L.) is the most strategic cereal crop in the world as well as in Egypt. It is considered first food grain consumed by human. The increasing demands of wheat is mainly due to the fast growth of human population. Therefore, maximizing wheat production can be achieved through increasing cultivated area, planting the high yielding varieties and appropriate agronomic practices such as seeding rates, N fertilizer levels and crop sequences. Appropriate crop positioning in cropping sequence under efficient management practices may facilitate better utilization of growth resources to enhance growth features. Several investigators showed that leguminous crops are the best precursors for all characters of wheat. Growing wheat after peas or fahl-berseem and/or soybean increased, plant height, number of spikes/m^2, spike length, number and weight of grains/spike as well as 1000-grain weight compared with wheat grown after fodder maize or maize **(Attia and Seif El-Nasr, 1993; Abou-Kresha, 1998 and Badr, 1999)**. On the other hand, number of tillers/plant and spikelets/spike and protein % were not significantly affected by preceding crops **(Badr, 1999)**. Grain and straw yields/fed of wheat grown after peas and fahl berseem were superior to wheat after fodder maize were 15.7, 15.1 and 13.1 ardab/fed, respectively **(Attia and Seif El-Nasr, 1993)**. Similarly, yield and yield components of wheat were greater when wheat was grown after maize/clover and soybean/clover (3-crop sequence) than when grown after maize (2-crop sequence) **Abou-Kresha (1998)**. Planting wheat after soybean resulted in an increase in grain yield/fed of 5.11% compared with maize and straw yield increased by 1.74%. Less N uptake by

legumes plants increased the N uptake by the following non-legume enhancing photosynthesis to increase photo assimilates translocation to plant different sinks and, in turn, enhancing yield and yield attributes **(Khalil *et al.*, 2011)**. Wheat cultivated after legumes has significantly higher grain and straw yields, net income and total cereal units than after cereal crop **(El-Mehy, 2007, Abou-Kerisha*et al.*, 2008 and Gangaiah*et al.*, 2012)**.

It is quite known that seeding rates and nitrogen fertilization greatly affected wheat productivity. Increasing N application significantly increased yield and yield components of wheat **(Attia and Seif El-Nasr, 1993 and Abou-Kresha, 1998)**. Plant height, spike length, number of spikelets and grains/spike, weight of spike and grains /spike and 1000-grain weight as well as grain protein content were significantly decreased by increasing seeding rates up to 60 kg/fed. Whereas, an increase in seeding rates significantly increased number of spikes/$m^2$and grain and straw yields/fed **(Toaima*et al.*, 2000; El-Gizawy and Al-Fagah, 2008 and Iqbal *et al.*, 2012)**. However, an opposite result was reported by **Saleh (2002)** who stated that varying seeding rates did not affect grain yield, 1000-grain weight and plant height. While, the lowest seeding rates (60 kg seeds/ha) gave lower number of spikes/m^2, higher number of spikelets and grains/spike and taller spikes compared with those of the higher seed rates (120 and 180 kg/ha). However, Increasing N levels from 75 to 150 or 225 kg N/ha caused significant increases in all characters studied **(Saleh, 2002, El-Agrodi *et al.*, 2011 and Iqbal *et al.*, 2012)**.Grain yield per plot and its yield components (number of fertile tillers, weight of 1,000 grains, ear weight and number of grains per ear) were evaluated genotypes with reduced tillering ability expressed an increase in grain yield with an increase in seeding densities, however showing a reduction in ear weight. The number of grains per ear did not affect grain yield but was highly influenced by seeding densities. The compensatory effect was expressed by the weight of a thousand grains as a function of the experimental conditions in which the genotypes were evaluated, regardless of seeding densities used **(Valerio *et al.*, 2013)**. **Abd El-Lattief (2014)** showed that the highest grain and straw yields as well as harvest index were recorded for (cv. Giza 168 and seeding 300 seeds m^{-2}), while the lowest values were found for (cv. Sohag 3 and seeding 100 seeds m^{-2}). There was no significant response to seeding rates in grain protein concentration.

The interaction between appropriate crop sequences and seeding rates and N fertilizer levels was significant for all studied traits in both seasons. The highest means were obtained when wheat was grown after maize/clover and soybean/ clover (3-crops systems) with application of 105 kg N/fed, while the lowest values resulted from sowing wheat after maize (2-crops systems) with 45 or 105 kg N/fed**Abou-Kresha(1998)**. Raising N levels after fahl berseem and fodder maize significantly increased 1000-grain weight, while it was not significant after peas **(Attia and Seif El-Nasr, 1993)**.

The present investigation aimed to study the effect of five crop sequences and four combination treatments between seeding rates and nitrogen fertilizer levels on growth, yield and its components of wheat.

Materials and Methods

Two field experiments were conducted during 2013/2014 and 2014/2015 seasons in Kafr El-Hamam Agriculture Research Station, Sharkia Governorates, ARC, to investigate the effect of five crop sequences on growth, yield and its components of wheat (cv. Sakha 94) which was treated with four combination treatments between seeding rates (50 or 60 kg/fed) and nitrogen fertilizer levels (60 or 75 kg/fed). Soil mechanical and chemical properties of the experimental site were determined before soil preparation according to **Black (1965)** as shown in Table (1-1). Soil samples were collected from (0-30cm layer) after catch crops, before seeding wheat, to determined soil content of available NPK. Available N and K % were determined using the standard method outlined by **Jackson (1973)** and available P% was determined calorimetrically according method of **Myrphy and Riley (1962)** in the two seasons as shown as in Table (1-2).

Table (1-1) Mechanical and chemical analysis of experimental site before planting maize in 2013/2014 and 2014/2015 seasons.

Characteristics	2013/2014	2014/2015	Characteristics	2013/2014	2014/2015
Mechanical analysis			Chemical analysis		
Fine sand%	29.5	29.9	EC	0.38	0.41
Silt%	24.7	25.5	pH	7.4	7.04
Clay%	45.8	44.6	Available N (ppm)	151	163
Soil texture	Clay	clay	Available P (ppm)	9.329	9.501
			Available K (ppm)	431	440

Table (1-2) Soil content of available NPK (ppm) before planting wheat in 2013/2014 and2014/2015

	2013/2014			2014/2015		
	N	P	K	N	P	K
Maize	115	4.952	381	95	4.084	440
Maize x potatoes	137	9.454	389	129	9.452	372
Maize/ fahl berseem	169	8.282	406	195	8.540	406
Maize/ peas	157	8.316	431	170	7.320	440
Maize/Fodder maize	83	4.080	372	87	4.274	389

Each experiment included 20 treatments which were arranged in split-plot design with three replications. Cropping sequences were allocated in main plots and seeding rates with nitrogen levels were in sub-plot treatments. Each sub-plot comprised 5 ridges x 70 cm = 3.5 m in width and 3.0 m length (plot area=10.5 m^2). Crop sequences in two seasons were as follows: maize/wheat (CS1), intercropping potatoes with maize/wheat (CS2), maize/fahl berseem/wheat (CS3), maize/peas/wheat (CS4), maize/ fodder maize/wheat (CS5). Seeding rates and nitrogen levels used for wheat were as follows: 50 kg seeds+60 kg N/fed (SN1), 50 kg seeds+75 kg N/fed (SN2), 60 kg seeds+60 kg N/fed (SN3), 60 kg seeds+75 kg N /fed (SN4).The cultivars used were maize (cv. Giza 324T.W.C), potatoes (cv. Diamond), peas (cv. Master- B), clover (cv. fahl berseem), fodder maize (cv. Giza 2), wheat (cv. Sakha 94) which was sown on ridges at 70 cm apart in 3rows (wheat grown on the same ridges of maize with minimum tillage). Nitrogen fertilizer was applied in form of urea (46% N) in two equal doses. Maize was grown in ridges at 70 cm apart in hills at 30 cm apart (plant/hill) for all crop sequences, except CS2 (intercropping potatoes with maize) which was sown on side of ridge in hills at 60 cm apart and thind to 2 plants/hill and potatoes was sown on another side of ridge in hills at 25 cm apart. It has been conducting germination process of potatoes tubers before 15 days of planting. Peas seeds were planted on double row in ridges at 70 cm apart. Fodder maize was sown on ridges in 3 rows in hills at 20 cm apart, while fahl berseem seeds were distributed in plots using the broadcast method. Overall, cultural practices for all crops production were undertaken as recommended. Planting and harvesting dates of crops in both seasons are presented in Table (2).

Table 2. Planting and harvesting dates of summer crop, catch crops and winter crop in 2013/2014 and 2014/2015 seasons.

Dates of planting and harvesting	Summer crop		Catch crops		Winter crop	
Crop sequence	Planting date	Harvesting date	Planting date	Harvesting date	Planting date	Harvesting date
			2013/2014 season			
Maize/Wheat (CS1)	1/6	19/9	-	-	5/12	11/5
Maize x potatoes/Wheat (CS2)*	1/6	19/9	18/8	2/12	5/12	11/5
Maize/fahlberseem/Wheat (CS3)	1/6	19/9	23/9	26/11	5/12	11/5
Maize/peas/Wheat (CS4)**	1/6	19/9	27/9	2/12	5/12	11/5
Maize/fodder maize/ Wheat (CS5)	1/6	19/9	23/9	26/11	5/12	11/5
			2014/2015 season			
Maize/Wheat (CS1)	6/6	23/9	-	-	11/12	23/5
Maize x potatoes/Wheat (CS2)*	6/6	23/9	14/8	8/12	11/12	23/5
Maize/fahlberseem/Wheat (CS3)	6/6	23/9	28/9	7/12	11/12	23/5
Maize/peas/Wheat (CS4)**	6/6	23/9	2/10	7/12	11/12	23/5
Maize/fodder maize/ Wheat (CS5)	6/6	23/9	28/9	3/12	11/12	23/5

*Intercropping potatoes with maize
**sowing peas seeds by Herati method

The following data were recorded for maize, catch crops and wheat characters.

Grain and straw yields of maize, tuber yield of potatoes, green pods yield of peas and fresh forage yield of fahl berseem and fodder maize were determined on the whole plot basis then it were transferred to tons/fed (Table 3).

At wheat harvest, ten plants were randomly collected from the inner ridges for each sub-plot to estimated plant height (cm), spike length (cm), number of spikelets/spike, spike weight (g), grains weight /spike (g) and 1000-grain weight (g). Number of tillers and spikes/m^2 were estimated from m^2. Grain and straw yields were determined from the yield data of the sub-plot then it was transferred to tons/fed.

Cereal units.

Cereal units calculation was conducted for whole year structure. Cereal units were proposed by **Brockhaus (1962)** to express agronomic gains from crops based on constituents of products either main-products or by-products. Cereal units for crops, estimated per 100kg, as follow:

Main product: maize and wheat = 1 unit, potatoes= 0.25 unit and green peas= 0.30 unit. **By product** maize straw=0.15 unit, wheat straw=0.15 unit, fahl berseem=0.14 unit, fodder maize=0.12 unit.

Table 3. Average yield of preceding crops of wheat in 2013/2014 and 2014/2015 seasons.

Crop sequence	Summer crop		Catch crops	Summer crop		Catch crops
	Main product ton/fed	By-product ton/fed	Main product ton/fed	Main product ton/fed	By-product ton/fed	Main product ton/fed
	2013/2014			2014/2015		
CS1	3.180	3.682	-	3.081	3.631	-
CS2	2.917	3.352	4.800	2.986	3.715	5.210
CS3	3.167	3.740	11.233	3.133	3.915	12.290
CS4	3.171	3.491	3.475	3.166	3.973	3.612
CS5	3.187	3.721	14.371	3.091	3.445	14.612

CS1 = maize/wheat, CS2=intercropping potatoes with maize/wheat, CS3=maize/fahl berseem/wheat, CS4=maize/peas/wheat, CS5=maize/ fodder maize/wheat

Economic evaluation:

The economic evaluation was used in this study based on the relation between inputs and outputs for different crop enterprise in the crop sequences. This was calculated from the production costs and prices in 2013/2014 season published by Department of Agric. Econ., Ministry of Agric., Egypt.Crop priceswere as follow:

-Grain wheat 2740 L.E/ton and straw 632 L.E/ton.
-Grain maize 2264 L.E/ton and straw 136 L.E/ton.
-Potatoes 1331 L.E/ton and peas 2708 L.E/ton.
-One cut of fahl berseem 3720 L.E and fodder maize 3000 L.E.

Competitive relationships:

Land equivalent ratio (LER) was calculated according to **Willey (1979)** using the following formula

$$\mathbf{LER} = \frac{Yab}{Yaa} + \frac{Yba}{Ybb}$$

Where: Yaa= pure stand yield of species a
Ybb= pure stand yield of species b
Yab= mixture yield of species a (when combined with b)
Yba= mixture yield of species b (when combined with a)

Land use efficiency or assessment of land use:

Multiple cropping which include both inter and sequential cropping has the main objective of intensification of cropping with the available resources in a given environment. Several indices have been proposed to compare the efficiencies of different multiple cropping system in turns of land use.

1. Multiple cropping index or multiple cropping intensity (MCI):

It was proposed by **Dalrymple (1971)**. It is the ratio of total area cropped in a year to the land area available for cultivation and expressed in percentage (sum of area planted to different crops and harvested in a single year divided by total cultivated area times 100).

$$\mathbf{MCI} = \frac{\sum_{i=1}^{n} ai}{A} * 100$$

Where, n is total number of crops, ai is area occupied by its crop and A is total land area available for cultivation. It is similar to cropping intensity.

$$\mathbf{MCI} = \frac{a1+a2+\cdots+an}{A} * 100$$

Where $a_1 + a_2 + \ldots + a_n$ is the gross cropped area and A the net cultivated area.

2. Cultivated Land Utilization Index (CLUI):

Cultivated land utilization index **(Chuang, 1973)** is calculated by summing the products of land area to each crop, multiplied by the actual duration of that crop divided by the total cultivated land times 365 days.

$$\mathbf{CLUI} = \frac{\sum_{i=1}^{n} ai\ di}{A*365} * 100$$

Where, n total number of crops; ai area occupied by its crop, di, days that its crop occupied and A = total cultivated land area available for 365 days. CLUI can be expressed as a fraction or percentage. This gives an idea about how the land area has been put into use. If the index is 1 (100%), it shows that the land has been left fallow and more than 1 (100%), tells the specification of intercropping or sequential.

Statistical analysis:

The statistical analysis of data was done according to **Gomez and Gomez (1984)**. Treatment means were compared using least significant difference (LSD at 0.05%) test as outlined by **Waller and Duncan (1969)**.

Results and Discussion

I-Effect of two and three crop sequences on wheat:

Response of all studied traits of wheat to crop sequences, which preceded wheat, (except no. of spikelets/spike in both seasons and straw yield in the 2nd season) were significant ($p < 0.05$) in both seasons (Tables 4 and 5). Results indicated that plant height and number of tillers and spikes/m^2 recorded the highest values when wheat plants were grown after fahl berseem (CS3) followed by peas (CS4) and potatoes (CS2), whereas the lowest values were after fodder maize (CS5) and maize (CS1). The differences

among peas and potatoes as preceding crops did not reach to level of significance in both seasons (Table 4).

Data presented in Tables (4 and 5) also indicated that spike characters (spike length, weight of spike and grains/spike) and 1000-grain weight were significantly affected by preceding crops and recorded maximum values when wheat was grown following fahl berseem (CS3) than it was grown after fodder maize (CS5). The differences among fahl berseem and peas as preceding crops were below the level of significance in both seasons, except grains weight of spike only in the second season. The results agree with those obtained by **Attia and Seif El-Nasr (1993) and Abou-Kresha (1998)**. On the other hand, number of spikelets/spike was not influenced by crop sequences in both seasons since this character is mainly considered as genetically ones. Similar result was also obtained by **Badr (1999)**.

Grain yield/fed of wheat was significantly affected by preceding crops in both seasons and straw in first season as shown in Table (5). Grain yield of wheat showed the same trend as yield component characters. The highest grain wheat yield was 2.959 and 2.980 ton/fed in CS3 after fhal berseem in the two seasons, respectively, and significantly surpassed that after non legumes in CS1, CS2 and CS5 by 16.73, 4.56 and 22.02% in the first season, and 11.57, 7.31 and 14.44% in the second season, respectively. It is worthy to note that in both seasons the highest grain yield after fahl berseem was the same grain yield obtained after peas, being (2.886 and 2.939 ton/fed), with an ignored difference. Similar effect was observed in straw yield irrespective to the insignificant impact of crop sequences on such trait in the 2nd season.

Cereal units, total incomes and net incomes of wheat gown after fahl berseem was superior to wheat grown following other cropping sequences (Tables 6-1 and 6-2). These results may be due to high soil content of N available after legume crops compared with non-legumes as shown in Table (1-2). Maximum total incomes and net incomes in CS3 were 10622 and 5422 L.E/fed in 1st season and 10659 and 5414 L.E/fed in 2nd season. However, the difference between fahl berseem and peas as preceding crops failed to reach level of significance in the first season.

Leguminous crop residues were effective in enriching the soil with nitrogen and organic matter, as well as improving the physical, chemical and biological characters may contribute much to the superiority of wheat when followed legume crops. Similar results were obtained by **Badr (1999), El-Mehy (2007), Abou-Kerisha *et al*, 2008 and Gangaiah *et al* (2012)**. Less N uptake by legumes plants increased the N uptake by the following non-legume (as shown in Table 1-2), enhancing photosynthesis to increase photo assimilates and its translocation to plant different sinks and, in turn, enhancing yield and yield attributes **(Khalil *et al.*, 2011)**.

II-Effect of seeding rates and N fertilizer levels on wheat:

Results presented in (Tables 4 and 5) show the effect of seeding rates under N levels on yield and yield attributes of wheat in the two seasons. Increasing N levels led to significant increase in plant height regardless of seeding rates in the two seasons. The present results indicate clearly the vital role of N in meristematic activity and stimulation of cell elongation in wheat plants. Similar result was reported by **Saleh (2002)**.

Seeding rates with N fertilizer levels had significant influences (P< 0.05%) in the both seasons on number of tillers and spikes/m^2. These characters were increased with increasing seeding rates from 50 to 60 kg seeds/fed and N fertilizer levels from 60 to 75 kg N/fed. Increases in number of tillers and spikes/m^2 are mainly due to the increase of the efficiency of plants to produce more tillers having more fertile spikes and consequently more spikes/m^2. These results were agreement with those obtained by **Attia and Seif El-Nasr (1993), Abou-Kresha (1998), Toaima*et al* (2000) and El-Gizawy and Al-Fagah (2008)**. Raising seeding rates from 50 to 60kg seeds/fed, under the same level of N fertilizer, decreased significantly spike length, number of spikelets/spike, weight of spike and grains/spike as well as 1000-grain weight in the two seasons. These results cleared that dense sowing led to a severe intraspecific competition among plants for nutrients, water supply and light. It is reflected on spike elongation and development as expressed in number of spikelets and weight of spike and grains/spike as well as 1000-grain weight. The results are in general agreement with those reported by **Toaima*et al* (2000), El-Gizawy and Al-Fagah (2008) and Valerio *et al* (2013)**. On the other hand, these traits progressively increased with increasing the nitrogen fertilizer rates from 60 to 75 kg N/fed. The maximum values of these characters were detected with SN2 (50 kg seeds + 75 kg N/fed) followed by SN4 (60 kg seeds + 75 kg N/fed) and SN1 (50 kg seeds + 60 kg N/fed), whereas the lowest values were detected at SN3 (60kg seeds + 60kg N/fed). These results added more support to those obtained by **Attia and Seif El-Nasr (1993), AbouKersha (1998) and El-Agrodi*et al* (2011)**. It worth to mention that the differences among the four combination treatments of seeding rates and nitrogen levels were significant (p< 0.05), except 1000- grain weight which was insignificant between SN2 and SN4 in the 1st season.

Grain and straw yields significantly increased due to increased seeding rates from 50 to 60 kg/fed and nitrogen levels from 60 to 75 kg/fed. The increments in grain yield were 5.86, 1.6 and3.59 % in first season and 6.45, 2.23 and4.94 % in the second season compared with SN1, SN2 and SN3, respectively. However, differences between SN4 (60kg seeds + 75kg N/fed) and SN2 (50 kg seeds + 75 kg N/fed) did not reach to level of significance, where the increase in number of spikes/m^2 with increase seeding rates was accompanied by a significant decrease in spike characters and 1000-grain weight. The increase in grain yield due to dense sowing may be attributed to increase in number of spikes/m^2. Meanwhile increasing N levels led to maximizing spike characters as well as 1000-grain weight. The increase in straw yield is mainly due to the increase in number of plants per area coupled with the increase in plant height. These results are in agreement with those obtained by **Attia and Seif El-Nasr (1993), AbouKersha (1998), El-Agrodi*et al* (2011) and Gangaiah*et al* (2012)** indicated that application of 120 kg N/ha to wheat had enhanced its productivity by 0.20 (grain) and 0.44 (straw) Mg*/ha, respectively over applied dose of N at 90 kg/ha. Likewise, increasing seeding rates from 45 to 90 kg/fed caused a significant increase in grain and straw yields **(El-Gizawy and Al-Fagah (2008) and Abd El-latif (2014)**. However, the opposite results reported by **Saleh (2002)** found that seeding rates did not affect grain yield in both seasons. This insignificant effect may be due to the opposite effects of seeding rates on spike length and number of grains/spikes.

The results in Tables (6-1 and 6-2) indicated that raising N application from 60 to 75 kg/fed and seeding rates from 50 to 60 kg/fed significantly increased cereal units by 7.59 and 7.50%, total incomes by 7.48 and 7.43% and total net incomes by 17.93 and 17.48% in the two seasons, respectively. The results obtained here are in good agreement with those reported by **Gangaiah*et al* (2012)** who stated that application of 120 kg N/ha to wheat is most economical, which has enhanced the net returns by $1.7x10^3$Rs**/ha over that 90 kg N/ha application.

III- **Interaction effect of crop sequences and seeding rates and N fertilizer levels:**

The data listed in Table (7) show significant interaction effect ($P< 0.05$) between crop sequences and seeding ratess with N fertilizer levels for plant height and 1000-grain weight in 1st season as well as spike length and weight in both seasons. All sequences revealed an increase in those traits with SN2 (50 kg seed + 75 kg N/fed). Such as that increase was significant when wheat plants were succeeded fahl berseem or peas. These results are in accordance with those obtained by **Attia and Seif El-Nasr (1993) and Abou-Kersha (1998).**

*Mg= mega grams (10^6 g) **Rs= Indian rupees

IV- Biological and economic evaluation and land use efficiency of the crop sequences:

Data presented in Table (8) detected clear difference in total cereal units which were produced from the main and by products of the crops of the different evaluated crops in the 5 sequences. The first position was recorded by the sequences (CS3) including fahl berseem, being 92.54 and 94.07 CUs followed by fodder maize in CS5 was 87.73 and 88.49 CUs in the two seasons, respectively. The third and fourth positions were earned by CS2 and CS4 including potatoes and peas as catch crops. It is may be due to major yield from forage crops compared with peas and potatoes. While the worst position was recorded by CS1 (Maize/wheat), being 71.82 and 72.19 CUs in two seasons.

Data tabulated in Table (9) showed that total net incomes and land use efficiency markedly increased in 3-crop sequence compared to 2-crop sequence. The highest total net incomes (13979 and 14284 L.E./fed) in two seasons respectively, were obtained by CS4 including peas as preceding crop of wheat. The second and third position of total net incomes earned by CS3 and CS2, respectively, while the lowest values of total net incomes being (6833 and 6949 L.E./fed) were observed by CS1. These results were agreement with this obtained by **El-Mehy (2007)**. Similarly, grown 3-crop sequence increased multiple cropping index (MCI) and cultivated land utilization index (CLUI) compared to 2-crop sequence. The highest CLUI value was obtained by crop sequence including fodder maize, being 1.55 and 1.57 and fahl berseem was 1.41 and 1.56 due to its high biomass productivity compared to peas and potatoes in two seasons, respectively. Whereas CS1 (2-crop sequence) recorded lower value of CLUI, 1.0 and 1.04 in two seasons, respectively. These results are in agreement with those obtained by **Panigrahy*et al* (2011)** who reported that where the land remains unutilized for a very short period, the CLUI attains a value near to 1.0, whereas for a completely unutilized land (throughout the year), the CLUI is 0.0. CLUI of Punjab was high due to the rice-wheat and cotton-wheat rotations in a considerable area, which kept most of the arable land occupied for most of the days of the year. As against this, West Bengal has a less CLUI due to a single crop in most of the area.

Conclusion

From the two years investigation, it is concluded that planting wheat after fahl berseem or peas as legume crops and supplied with 75 kg N/fed at 50 or 60 kg seeds/fed is recommended to produce the maximum value of wheat grain yield/fed, total cereal units and total net income. The inclusion of a third (catch) crop in the Egyptian crop structure will certainly increase the cereal units, net incomes, multiple cropping index(MCI) and cultivated land utilization index (CLUI) of cropping sequence **.**

Table 4. Effect of crop sequences, seeding rates and N fertilizer levels on growth and some yield components of wheat in 2013/2014 and 2014/2015 seasons.

Traits / Treatments	Plant height (cm)		No. of tillers/m^2		No. of spikes /m^2		Spike length (cm)		No. of spikelets /spike	
	2013/2014	2014/2015	2013/2014	2014/2015	2013/2014	2014/2015	2013/2014	2014/2015	2013/2014	2014/2015
Crop sequence (A)										
CS1	100.2	105.7	364.00	396.67	360.67	391.58	9.09	9.07	18.91	18.63
CS2	103.7	106.7	385.58	410.25	380.00	406.00	9.43	9.25	19.23	19.03
CS3	106.6	110.3	417.50	430.33	412.58	426.42	10.23	10.18	19.49	19.31
CS4	106. 6	107. 8	391.75	415.17	385.75	410.00	9.81	9.87	19.38	19.06
CS5	98. 7	93.7	329.08	379.67	318.17	374.25	9.02	9.07	18.65	18.59
LSD at 5%(A)	5.2	1.61	16.93	13.51	20.92	12.87	0.67	0.68	N.S	N.S
Seeding rates& N levels (B)										
SN1	97. 3	104.3	351.93	395.13	345.67	386.67	9.28	9.15	19.00	18.72
SN2	110.5	108.9	370.27	400.93	375.27	399.93	10.50	10.21	19.63	19.95
SN3	95.1	97.9	386.20	408.87	378.53	408.93	8.59	8.69	18.61	17.88
SN4	109.9	108.1	401.93	420.73	386.27	411.07	9.68	9.9	19.29	19.13
LSD at 5%(B)	3.0	1.97	20.80	12.62	21.17	11.85	0.31	0.27	0.46	0.36
LSD at 5% AxB	6.8	N.S	N.S	N.S	N.S	N.S	0.69	0.59	N.S	N.S

CS1 = maize/wheat, CS2=intercropping potatoes with maize/wheat, CS3=maize/fahlberseem/wheat, CS4=maize/peas/wheat, CS5=maize/ fodder maize/wheat.
SN1 (50 kg seeds+60 kg N/fed), SN2 (50 kg seeds+75 kg N/fed), SN3 (60 kg seeds+60 kg N /fed), SN4 (60 kg seeds+75 kg N /fed).

Table 5. Effect of crop sequences, seeding rates and N fertilizer levels on yield and yield components of wheat in 2013/2014 and 2014/2015 seasons.

Traits / Treatments	Spike weight (g)		Grains weight / spike (g)		1000-grain weight (g)		Grain yield (t/fed)		Straw yield (t/fed)	
	2013/2014	2014/2015	2013/2014	2014/2015	2013/2014	2014/2015	2013/2014	2014/2015	2013/2014	2014/2015
Crop sequence (A)										
CS1	2.66	2.53	1.87	1.79	40.31	40.02	2.535	2.671	3.661	3.689
CS2	2.85	2.65	2.05	1.96	41.28	40.92	2.830	2.777	3.879	3.734
CS3	3.09	3.03	2.23	2.13	42.72	42.66	2.959	2.980	3.977	3.945
CS4	2.88	2.71	2.17	2.05	42.06	40.62	2.886	2.939	3.932	3.582
CS5	2.50	2.13	1.75	1.48	39.45	38.02	2.425	2.604	3.517	3.536
LSD at 5%(A)	0.27	0.39	0.15	0.44	1.30	2.34	0.14	0.11	0.26	N.S
Seeding rates& N levels (B)										
SN1	2.60	2.42	1.87	1.74	40.81	40.34	2.646	2.713	3.531	3.500
SN2	3.39	2.98	2.44	2.15	43.13	42.22	2.757	2.825	3.793	3.612
SN3	2.17	2.12	1.56	1.53	38.95	37.99	2.704	2.752	3.867	3.799
SN4	3.03	2.93	2.14	2.11	41.77	41.25	2.801	2.888	3.983	3.877
LSD at 5%(B)	0.13	0.19	0.11	0.15	0.78	1.57	0.06	0.07	0.13	0.19
LSD at %AxB	0.27	0.43	N.S	N.S	1.75	N.S	N.S	N.S	N.S	N.S

CS1 = maize/wheat, CS2=intercropping potatoes with maize/wheat, CS3=maize/fahlberseem/wheat, CS4=maize/peas/wheat, CS5=maize/ fodder maize/wheat.
SN1 (50 kg seeds+60 kg N/fed), SN2 (50 kg seeds+75 kg N/fed), SN3 (60 kg seeds+60 kg N /fed), SN4 (60 kg seeds+75 kg N /fed).

Table (6-1) Effect of crop sequences, seeding rates and N fertilizer levels on cereal units, total income and total net income of wheat in 2013/ 2014 and 2014/2015 seasons.

Traits / Treatments	Cereal units		Total incomes (L.E/fed)		Total net incomes (L.E/fed)	
	2013/2014	2014/2015	2013/2014	2014/2015	2013/2014	2014/2015
Crop sequence (A)						
CS1	34.50	35.93	9259	9651	4059	4406
CS2	38.00	37.10	10204	9968	5006	4723
CS3	39.54	39.67	10622	10659	5422	5414
CS4	38.69	38.35	10392	10317	5191	5071
CS5	33.04	34.87	8866	9366	3666	4121
LSD at 5% (A)	1.67	1.04	446	265	416	265
Seeding rates & N levels (B)						
SN1	35.29	35.88	9481	9646	4351	4336
SN2	37.06	37.28	9953	10022	4728	4798
SN3	36.70	37.00	9850	9937	4675	4760
SN4	37.96	38.57	10190	10363	4919	5094
LSD at 5%(B)	0.71	0.55	191	144	191	144
LSD at 5% AxB	N.S	N.S	N.S	N.S	N.S	N.S

Table (6-2) Effect of crop sequences, seeding rates and N fertilizer levels on cereal units, total income, cost and total net income of wheat in 2013/ 2014 and 2014/2015 seasons.

Crop sequences	Seeding rates &N fertilizer levels kg/fed	Cereal units		Total income (L.E/fed)		Cost (L.E/fed)		Net income (L.E/fed)	
		2013/2014	2014/2015	2013/2014	2014/2015	2013/2014	2013/2014	2013/2014	2014/2015
CS1	SN1	33.10	34.25	8887	9206	5130	5130	3757	3896
	SN2	34.78	36.37	9334	9775	5224	5224	4110	4551
	SN3	35.60	35.37	9549	9493	5177	5177	4372	4316
	SN4	34.54	37.76	9268	10130	5271	5271	3997	4859
CS2	SN1	36.14	35.89	9720	9645	5130	5130	4590	4335
	SN2	37.86	37.33	10167	10029	5224	5224	4943	4805
	SN3	37.30	37.00	10006	9932	5177	5177	4829	4755
	SN4	40.69	38.19	10931	10268	5271	5271	5660	4997
CS3	SN1	37.87	38.64	10177	10386	5130	5130	5047	5076
	SN2	40.40	39.91	10858	10731	5224	5224	5634	5507
	SN3	39.17	39.62	10518	10637	5177	5177	5341	5460
	SN4	40.71	40.50	10936	10883	5271	5271	5664	5612
CS4	SN1	37.72	36.68	10144	9874	5130	5130	5014	4564
	SN2	38.86	38.11	10439	10254	5224	5224	5215	5030
	SN3	38.25	38.57	10274	10369	5177	5177	5097	5192
	SN4	39.91	40.02	10710	10769	5271	5271	5439	5498
CS5	SN1	31.60	33.95	8479	9120	5130	5130	3349	3810
	SN2	33.39	34.67	8964	9322	5224	5224	3740	4099
	SN3	33.20	34.45	8914	9255	5177	5177	3737	4078
	SN4	33.96	36.39	9107	9766	5271	5271	3836	4495
LSD at 5% (A)		1.67	1.64	448	265	N.S	N.S	449	265
LSD at 5% (B)		0.71	0.55	192	144	0.10	0.10	192	144
LSD at 5% AxB		N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

CS1 = maize/wheat, CS2=intercropping potatoes with maize/wheat, CS3=maize/fahlberseem/wheat, CS4=maize/peas/wheat, CS5=maize/ fodder maize/wheat.
SN1 (50 kg seeds+60 kg N/fed), SN2 (50 kg seeds+75 kg N/fed), SN3 (60 kg seeds+60 kg N /fed), SN4 (60 kg seeds+75 kg N /fed).

Table 7. Interaction effect of crop sequences, seeding rates and N fertilizer levels on growth and yield components of wheat in 2013/2014 and 2014/2015 seasons.

Crop sequences	Seeding rates &N fertilizer levels kg/fed	Plant height (cm)		Spike length (cm)		spike weight (g)		1000-grain weight (g)	
		2013/2014	2014/2015	2013/2014	2014/2015	2013/2014	2014/2015	2013/2014	2014/2015
CS1	SN1	95.37	104.77	9.10	8.97	2.26	2.33	39.59	39.90
	SN2	101.98	109.60	10.37	9.37	3.34	2.74	41.51	42.73
	SN3	96.53	103.70	7.73	8.73	2.17	2.13	38.52	38.97
	SN4	107.03	104.67	9.17	9.20	2.61	2.63	40.46	39.63
CS2	SN1	100.90	105.27	9.30	8.93	2.59	2.60	40.70	41.30
	SN2	111.70	108.27	9.90	9.97	3.50	2.97	42.03	42.63
	SN3	90.67	103.17	8.77	8.27	2.34	1.97	39.59	39.30
	SN4	111.70	109.93	9.73	9.83	2.68	2.77	41.36	41.90
CS3	SN1	100.23	108.47	9.83	9.43	2.98	3.20	42.04	43.90
	SN2	118.43	113.37	11.40	11.27	3.53	3.21	44.57	43.87
	SN3	94.97	106.53	9.50	8.93	2.23	2.32	40.32	39.83
	SN4	112.77	112.67	10.17	11.07	3.39	3.12	43.70	43.27
CS4	SN1	99.63	106.30	9.47	9.60	2.71	2.42	40.18	40.53
	SN2	113.30	109.63	10.50	10.70	3.62	3.29	42.41	44.83
	SN3	99.63	105.07	9.33	9.03	2.16	2.30	39.02	38.97
	SN4	113.67	110.13	9.93	10.13	2.71	2.54	40.86	43.90
CS5	SN1	104.10	103.23	9.40	9.27	2.37	2.18	39.85	40.13
	SN2	106.90	104.07	10.33	9.73	2.94	2.66	40.55	41.57
	SN3	93.63	70.83	7.63	8.46	1.96	1.83	32.46	37.70
	SN4	90.03	96.47	8.70	8.80	2.43	1.55	39.20	8.40
LSD at 5% AxB		6.8	N.S	0.69	0.59	0.27	0.43	1.75	N.S

CS1 = maize/wheat, CS2=intercropping potatoes with maize/wheat, CS3=maize/fahlberseem/wheat, CS4=maize/peas/wheat, CS5=maize/ fodder maize/wheat.
SN1 (50 kg seeds+60 kg N/fed), SN2 (50 kg seeds+75 kg N/fed), SN3 (60 kg seeds+60 kg N /fed), SN4 (60 kg seeds+75 kg N /fed).

Table 8. Effect of crop sequences on cereal units of sequences (whole year structure) in 2013/2014 and 2014/2015seasons.

Crop sequence	Summer crop		Catch crops	Winter crop		Summer crop		Catch crops	Winter crop		Total CU.s of sequence	
	Main product	By product	Main product	Main product	By product	Main product	By product	Main product	Main product	By product		
	2013/2014					**2014/2015**					**2013/2014**	**2014/2015**
CS1	31.80	5.52	-	25.35	9.15	30.81	5.45	-	26.71	9.22	71.82	72.19
CS2	29.17	5.03	12.00	28.30	9.70	29.86	5.57	13.03	27.77	9.34	84.20	85.57
CS3	31.67	5.61	15.73	29.59	9.94	31.33	5.87	17.21	29.80	9.86	92.54	94.07
CS4	31.71	5.24	10.43	28.86	9.83	31.66	5.96	10.84	29.39	8.96	86.07	86.81
CS5	31.87	5.58	17.24	24.25	8.79	30.91	5.17	17.53	26.04	8.84	87.73	88.49

Table 9. Effect of crop sequences on total net income and land use Efficiency in 2013/2014 and 2014/2015 seasons.

		Summer crop			Catch crops			Winter crop	Total net income of sequence (L.E/fed)	LER**	MCI %	CLUI	CLUI %
		Total income (L.E/fed)	Cost (L.E/ fed)	Net income (L.E/fed)	Total income (L.E/fed)	Cost* (L.E/ fed)	Net income (L.E/fed)	Net income (L.E/fed)					
CS1	2013/2014	7701	4927	2774	-	-	-	4059	6833	1	200	1	100
	2014/2015	7470	4927	2543	-	-	-	4406	6949	1	200	1.04	104
CS2	2013/2014	7061	4927	2134	6389	5031	1358	5006	8497	1.48	300	1.17	117
	2014/2015	7266	4927	2339	6935	5031	1904	4723	8966	1.51	300	1.27	127
CS3	2013/2014	7680	4927	2753	3720	741	2979	5422	11154	1	300	1.41	141
	2014/2015	76267	4927	2699	3720	741	2979	5414	11092	1	300	1.56	156
CS4	2013/2014	7655	4927	2728	9410	3350	6060	5191	13979	1	300	0.88	88
	2014/2015	7709	4927	2782	9781	3350	6431	5071	14284	1	300	0.98	98
CS5	2013/2014	7722	4927	2795	3000	618	2382	3666	8842	1	300	1.55	155
	2014/2015	7467	4927	2540	3000	618	2382	4121	9043	1	300	1.57	157

*Total variable cost/fed of catch crop without rent ** LER for potatoes intercropping with maize

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تأثر محصول القمح ومكوناتة بالتعاقب المحصولى ومعدلات التقاوى والتسميد النتروجينى

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أقيمت تجربتان حقليتان بمحطة البحوث الزراعية بكفر الحمام (محافظة الشرقية) خلال موسمى 2014/2013، 2015/2014 لدراسة تأثير خمس تعاقبات محصولية تسبق القمح (ذرة شامية ثم قمح – بطاطس محمله على ذرة شامية ثم قمح – ذرة شامية ثم برسيم فحل ثم قمح – ذرة شامية ثم بسلة ثم قمح – ذرة شامية ثم دراوة ثم قمح) وأربع معاملات توافقية بين معدلات التقاوى ومستويات السماد النتروجينى (50 كجم تقاوى + 60 كجم ن /ف)، (50 كجم تقاوى + 75 كجم ن /ف)، (60 كجم تقاوى + 60كجم ن /ف)، (60 كجم تقاوى + 75 كجم ن /ف). وكان التصميم المستخدم القطع المنشقة مرة واحدة فى ثلاث مكررات حيث تمثل القطع الرئيسية التعاقبات المحصولية بينما وضعت معدل التقاوى والتسميد النتروجينى بالقطع الفرعية. **ويمكن تلخيص أهم النتائج المتحصل عليها كالأتى:**

1-أثرت التعاقبات المحصولية على إرتفاع النبات، عدد الأشطاء والسنابل/م^2، طول ووزن السنبلة، وزن حبوب السنبلة، وزن 1000 حبة، محصول القمح من الحبوب والقش /ف وكذلك على وحدات الحبوب، إجمالى الدخل وصافى الدخل معنوياً فى كلا الموسمين. وأدت زراعة القمح عقب المحاصيل البقولية (البرسيم الفحل و البسلة) إلى زيادة محصول الحبوب وصافى الدخل مقارنة بالزراعة بنظم التعاقبات الأخرى.

2- أدى زيادة معدل تقاوى القمح من50 إلى 60 كجم/ف إلى زيادة معنوية فى عدد الأشطاء والسنابل/م^2 ، محصول الحبوب والقش وصافى الدخل /ف ونقص معنوى فى صفات السنبلة ووزن ال1000 حبة.

3- زادت جميع صفات القمح تدريجياً بزيادة التسميد النتروجينى من 60 إلى 75 كجم /ف، وسجلت أعلى القيم للصفات المدروسة بزراعة القمح بمعدل 60 كجم تقاوى +75 كحم ن/ف، يليه معدل 50 كجم تقاوى+ 75 كجم ن/ف فى كلا الموسمين.

4- أظهر التفاعل بين التعاقبات المحصولية ومعدلات التقاوى والتسميد النتروجينى تأثير معنوى على إرتفاع النبات، طول السنبلة، وزن حبوب السنبلة ووزن ال1000 حبة.

الخلاصة:- توصي الدراسة بزراعة القمح عقب البرسيم الفحل بمعدل تقاوي 50 أو60 كم /ف مع التسميد ب75 كجم سماد نتروجينى /ف لتحقيق أعلى محصول من الحبوب. وأدت الزراعة المكثفة إلى زيادة معنوية فى إجمالى وحدات الحبوب، العائد الأقتصادى، صافى الدخل/ف ومعامل التكثيف مقارنة بالزراعة التقليدية. حيث حقق التعاقب الرابع (ذرة شامية/بسلة/قمح) أعلى عائد إقتصادى14131 جنية/ف كمتوسط للموسمين.