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Relay Intercropping of Cotton with Wheat under Different Nitrogen Fertilizer Levels

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THE CURRENT study was conducted at Sers El-Lian Research Station, Minufiya Governorate, Egypt, during 2009/10 and 2010/11 years to investigate the effect of three cropping patterns of relay cotton (Var. Giza 85) on wheat (Var. Sakha 93) as well as monoculture regarding growth, yield and its attributes . The study also targeted examination of five nitrogen levels and source. Competitive relationship parameters and economical input/ output variables for the entire field railing were justified too. The three tested intercropping patterns showed diverse traits between the two years of study (P 0.05) associated with interaction years and patterns main effect of the 90cm-traces pattern (P_2) recorded significantly greater yields of both wheat and cotton traits than the other two cropping patterns . Effects of nitrogen levels showed insignificance difference between the treatment 70 kg mineral N + 500g cerialein, compared to the recommended dose of 75 kg mineral nitrogen. Interaction between planting patterns and nitrogen levels concluded exploiting P_2 pattern and the treatment 70kg mineral N+500g cerialein. Land equivalent ratio(LER),relative crowding coefficient (RCC) and estimates averaged over cropping patterns and N-fertilizer treatments showed increasing the efficiency of land use by 76% and 82% in the first and second year, respectively. Moreover, the most benefit realized was associated with post plantation cotton intercropped with wheat expressed as monetary advantage index (MAI) of (5446.8 and 5537.7 LE) in the first and second season ,respectively. The total income was the highest when relay intercropping cotton were grown with cotton at 90 cm traces pattern P_2 and using 75 kg mineral N/fed in both seasons, respectively . It could be concluded that relay intercropping of cotton with wheat as intensive cropping system is recommended to increase the productivity of the unit area.

Keywords: Relay intercropping, Egyptian cottons, Wheat, Nitrogen levels; LER; MAI, Total income.

Egyptian cotton (*Gossyptium barbadense* L.) of long and extra long stable and bread wheat (*Triticum aestivum* L.)are two major crops grown in Egypt since ancient times. The last report of Industrial Development Authority indicated that 452 textile mills were established from Jan. 2006 to Jan. 2009. The investments amounted to 7.6 billion Egyptian pounds, most likely, to provide extra 80 thousands employment opportunities. Recently, Egyptian cotton has been suffering from many domestic and world market difficulties. One of the most cotton farming problems is delaying planting date after March, 30. This mainly was due to time overlapping with the preceding winter liquid money crops like wheat or faba bean. For these reasons, the long duration winter crops especially wheat was not encouraging to sow before cotton (Kamel *et al.,* 1992). Wheat , on the other hand , is also food and feed crops and with more than 15% of needs is imported, it makes a huge noisy to the police makers in Egypt. It is the most important cereal crop for providing the every-morning source of carboy dates and probably protein to the growing Egyptian nation.

Several production systems like planting pattern rows orientation, crop rotation, mixing- cropping, intercropping and relay cropping of major crops with the others are proposed by agronomists to yield production and land use.

The word relay in its agricultural meaning is describing the case of inter-planting a crop (second crop) into an existing crop (first crop) several weeks right before harvesting the first one. Rely intercropping is then a method of multiple cropping where summer crops, like cotton in the current study, are plated into standing winter crop (wheat) several weeks before winter wheat harvested (4 to 7 weeks). Under Egyptian conditions, while wheat is about to be mature.

The affect of relay intercropping of cotton with wheat was studied by Hussein (2006) and Zhang *et al.* (2007). Those articles highlighted that relay intercropping pattern gave advantage in land use efficiency estimates over the patterns using several crop intensification sequences and wheat- relay intercropping. El-Hawary (2009) concluded that relay intercropping with cotton was superior over all cropping successions used and also recorded the highest mean net returns especially for water consumption. In addition to the above-mentioned points the current is extended to research the levels and source nitrogen added to wheat this is to maintain the sustainable agriculture that requires a profound concern for environmental safety and increase in cost of chemical fertilizers the application of mineral fertilizer recommended for wheat under Egyptian conditions mounts to 75 kg feddan^{-1} this amount is more than 3 times of the world average (Zhang *et al.,* 2008). As a consequence, the high rates of mineral N management in cropping patterns will crops growing environment and food provisions in a severe risk to date, there is no exact recommendation on how much N- fertilize are applied to wheat when relayed with cotton instead it is presumable as high as the above mentioned rate thus improving the nitrogen use efficiency is an objective of both agronomist. Mekhemar (2008) found that inoculation of wheat grain with N-bio- fertilizers resulted increase in growth and yield traits and Sherif *et al.* (2011), indicated that all intercropping treatments showed yield advantage compared with solid planting and the maximum value of land equivalent ratio LER were 1.97 and 1.88 in both seasons, respectively.

The present study exploited cerialine as N bio-fertilizer. It is a commercial product produced by bio- fertilizers unit, A.R.C. Egypt containing azotobacter and azospirllum bacteria. The study was designed to promote sustainability over time and space through evaluating biologically as well as economically, relaying Egyptian cotton on wheat response of wheat and cotton plants to relay cropping patterns including sole and nitrogen fertilizer levels and source were aimed.

Materials and Methods

The current study was conducted at Serce EL-Lian Research Station, Minufiya Governorate, Egypt during 2009/10 and 2010/11 years. The study aimed to sustain Egyptian cottons cultivated space through investigating the effect of three cropping systems of relay cotton (var. Giza 85) on wheat (Var. Sakha 93) regarding growth and yield and its attributes. The study also targeted examination of five nitrogen levels and source. Competitive relationship parameters and economical input/output variable for the entire field trialing were justified too. The soil texture of experimental area was clay loam. Table 1 illustrated the soil loam analysis of the experimental site for the two years of experimentation.

TABLE 1. Soil loam chemical and physical analysis in the two years of experimentation.

				Marcro-nutrients(ppm)			Mechanical analysis (%)			
Year	**pH**	**$CaCO_3$**	**O.M.%**	**N**	**P**	**K**	**Clay**	**Silt**	**Fine sand**	**Course sand**
2009/2010	7.3	1.3	1.2	8.9	14	138	40	27	33	1.3
2010/2011	7.6	1.4	1.5	12.4	12	125	38	27	32	1.4

In case of rely cropping winter wheat, sown in the fall, is intercropped with cotton in the spring. After wheat harvesting in early summer, cotton occupies the whole land. At cotton harvest, in the next fall, two crops have been grown in one field, with seedling and early reproduction phase of cotton and the maturation phase of wheat overlapping in time and space. Cropping cycle can be restarted again by planting wheat in fall.

Therefore, the geometrical arrangements of the cropping patterns in the current study occupied the main plots with plot size of 42 m^2. Planting patterns of cotton and wheat were done on terraces where wheat grains were sown in rows 15. Cotton seeds was sown two plants in hills, 25 cm apart seeded on the side of the bed. Cropping patterns were depicted as follow: Pattern 1 (P_1); cotton was seeded in pure stand in dry soil in rows 60 cm apart and one side of the ridges (60 cm width). The cotton seeds were planted at March 23rd and 22nd in the first and second seasons, respectively, in hills 25 cm apart with seeding rate of 30 kg/fed, and the plants were thinned to two plants/hill. This pattern was designed for testing the late plating of cotton after traditional wheat cultivation following the integrated late planting cotton package described by Abou El-Zahab & Mashhour (1998) where they recommended cotton variety G 85 as a tolerant to stress of late planting. The experimental area was prepared for regular planting of wheat on Nov. 15th and 20th in the two years, respectively. cotton plants were thinned to two plants per hill and the agricultural management for both crops was followed as sole planting. Pattern 2 (P_2) and pattern 3 (P_3); cotton relayed on wheat terraces of 90 cm apart and 120 cm apart, respectively , using the above- mentioned planting format. In P_2 and P_3 , cotton was relayed on March 22nd and 23rd, while wheat was planted Nov. 15th and 21st in the first and second season, respectively. Cotton seeds were sown prior to the irrigation of wheat in the two sides of the terraces in hills, 25 cm apart, respectively. In order to find out a means of valid comparison, level of both traditional solid cotton and wheat was applied. The traditional planting wheat grains were sown in rows 15cm apart on Nov. 15th and 21st, respectively, in the two years. The cultural practices for both crops were followed as the site recommendations.

Five treatments of nitrogen fertilization, occupied the sub-plots, were used to investigate response of wheat yield to N fertilizer level. These treatments were: Without fertilizer (control treatment), only 500 gm of cerialein/fed and only 75kg mineral N/fed. Nitrogen fertilizer was added in the form of ammonium nitrate (33.5% N). Mineral nitrogen fertilizer treatments were added in two equal doses. Wheat grains were divided into two parts: first, was washed with water just before planting to remove the races of pesticide and directly inoculated with cerialein. Second, was left without washing. At cotton harvest, three inner ridges and terraces were used to collect information about seed cotton yield and its components. Ten guarded plants used to estimate plant height/cm (pH), number of fruiting branches/plant (NFB), number of open bolls per plant (NOB), lint percent (L%), seed index (SI) "weight of 100 seed per gm". Boll weight was as average of 50 bolls selected randomly from each plot. Seed cotton yield per plant (SCY/plant) and per feddan in kantars (SCY/KF). Seed cotton yield per plot in kg was transformed to kantars per feddan (1 kentar = 157.5 kg). At wheat harvest all plants in each sub-plot were used to determine wheat grains yield ardab/fedden (1 ardab=150 kg). Ten guarded plants were chosen from each plot to estimate yield determinants like number of spike/m^2, spike length, number of spikelets/spike, number of grains/spike, spike weight, grain weight (gm/spike), 1000-grains weight (seed index) and grain yield (gm/plant). Plant height (cm), straw yield (ton/fed) and protein content (kg/fed) were estimated.

Statistical analysis

The experimental 15 treatments were laid-out in four replicates of RCBD with split plot arrangements. The main plots of 42 m^2 were allocated to the cropping systems. The five nitrogen fertilizations levels were distributed in the sub-plots. The competitive relationships and yield advantage variables were land equivalent ratio "LER" (Willey 1979, 1990), relative crowding coefficient "RCC" (Dewit, 1960) and aggressively (Mc-Gilehrist, 1965).

Monetary advantage index (MAI)

It suggests that the economic assessment should be in terms of the value of land saved; this could probably be most assessed on the basis of the rentable value of this land .MAI was calculated according to the formula suggested by Willey (1979) .

$$MAI = \frac{\text{value of combined intercrops x LER-1}}{\text{LER}}$$

Economic evaluation

The net income fed^{-1} was calculated for each treatment in Egyptian pounds, using the market prices for both years. The market prices for wheat 210.00 L.E. ardab^{-1} average in the two successive seasons and 670.00 L.E kentar $^{-1}$ for cotton average in the two successive seasons (Agriculture Statistics 2009 and 2010). Moreover, profitability was calculated for each treatment according to the following formula:

Profitability = (Net benefit / total variable cost) x 100.

Results and Discussion

The current study was designed to enhance Egyptian cotton sustainability by justifying the sustainability dimensions include social acceptance, environmental health and economic benefits. This practically mean to check if relay intercropping of cotton on wheat is sustainable *i.e.* environmental resources (land, fertilizer and other agro economic variables) use efficient compared with regular cropping .

Effect of planting patterns

Planting pattern was deliberated to help sustain Egyptian cotton cultivated area through investigating the response of cotton plants to different planting patterns including monoculture, late planting cotton after wheat (P_1) and two relay cropping of cotton on wheat (P_2 and P_3). Results presented in Table 2 indicated that relay intercropping of wheat and cotton provides a substantial wheat yield advantage compared to monoculture. The two tested intercropping system showed diverse traits between the two years of study ($P>0.05$) associated, however, with no interaction between years and patterns. The 90 cm double rows pattern system (P_2) had significantly greater wheat yield than the other two cropping patterns. Wheat traits significantly affected by cropping pattern, except for no of spikelet/ spike and straw yield in both seasons. Among the three cropping patterns, P_2 pattern gave highest wheat yields (21.70 and 22.40 ardab/fed for the two years, respectively) followed by pattern 3 (120 cm double rows pattern system) with no clear cut significant difference between P_1 and P_3. The three cropping varied in grain yields/ fed compared to the solid case and amounted to 88%, 95% and 88%, for first year and 84%, 89% and 86% for second year, respectively. This bared that relaying cotton on wheat had minor deleterious effects on wheat growth, yield and yield components. Wheat plants raised on P_2 tended to have better growth, yield and yield components than those grown on the conventional rows P1.

TABLE 2. Effect of planting pattern in growth ,yield and yield component of wheat during 2009/2010 and 2010/2011 seasons.

Cropping pattern	Plant height (cm)	No of spikes m^2	Spike Length (cm)	No of spikelets/ spike	Weight of spike(g)	No of grains/ spike	Seed index (g)	Grain yield arada/ fed	Straw yield (ton)/ fed	Protein kg/fed
Season 1										
P_1	92.23	364.48	11.31	18.53	2.23	50.41	43.09	20.21	4.57	214.91
P_2	92.35	377.58	11.55	18.68	2.58	54.75	46.22	21.70	5.44	233.29
P3	94.04	368.74	11.49	18.6	2.37	51.76	44.93	20.18	4.9	211.48
LSD	1.05	14.75	0.20	Ns	0.23	0.27	1.31	0.47	Ns	14.12
CV%	3.74	5.81	4.88	2.2	2.72	3.75	3.15	3.38	3.65	8.17
Solid	69.17	380.35	12.24	18.83	2.69	59.4	53.22	22.90	5.14	240.2
Performance percentage										
P_1	0.93	0.96	0.92	0.98	0.83	0.85	0.81	0.88	0.89	0.85
P_2	0.93	0.99	0.94	0.99	0.96	0.92	0.87	0.95	0.88	0.92
P3	0.98	0.97	0.94	0.98	0.88	0.87	0.84	0.88	0.95	0.83
Season 2										
P_1	87.37	372.29	11.51	18.43	2.31	51.94	44.56	21.06	4.56	243.23
P_2	90.78	394.03	11.96	18.65	2.66	57.57	46.93	22.4	4.39	260.65
P3	94.94	381.2	11.82	18.49	2.39	56.32	45.29	21.53	4.83	235.72
LSD	2.35	8.27	0.32	Ns	0.31	1.69	0.56	1.43	Ns	11.84
CV%	4.5	6.86	3.63	3.32	2.51	3.67	3.4	3.52	2.14	6.6
Solid	97.25	415.1	12.37	18.84	2.77	65.08	58.14	23.15	5.11	265.07
Performance percentage										
P_1	0.90	0.90	0.93	0.98	0.83	0.80	0.77	0.84	0.89	0.92
P_2	0.93	0.95	0.97	0.99	0.96	0.88	0.81	0.89	0.86	0.98
P3	0.98	0.92	0.96	0.98	0.86	0.87	0.78	0.86	0.95	0.89

Growing wheat on wide ridges seemed to minimize both below and above ground inter –competition and increased the benefit from solar radiation. This indicating different response of wheat plants sown in different cropping patterns including monoculture back to response to crop density. Thus, increases in grain yield, straw yield and protein in solid planting may be due to the effect of growing wheat on narrow rows. On the other hand, data in Table 3 revealing the effect of planting cotton late after wheat (P_1) and the two relay intercropping patterns P_2 and P_3 on cotton growth, yield and some of its components. Cotton lint yields were significantly lower in intercrops than in monoculture ($P>0.05$). The yields of the monoculture were 7.90 and 7.33 kantar fed for in the first and second year, respectively, with a significant year effect ($P>0.05$). Except for plant height and seed index, significant variation was recorded with other treats in the two years. No of fruiting branches plant, no of open bolls plant, boll weight gm, yield plant (gm), lint %, and seed cotton yield kantars/ fed were the highest significantly when cotton relayed on wheat in the second pattern of both seasons. Production of cotton yields fed were the highest in the pattern 2 followed by pattern 3 and amounts to 89% and 84% of monoculture in the first season and 96% and 90% in the second season, respectively.

TABLE 3. Effect of planting pattern on growth , yield and yield component of cotton during 2009/2010 and 2010/2011 seasons.

Pattern cropping	PH (cm)	NFB/ plant	NOB/ plant	BW/gm	SCY/ plant(gm)	SI	L %	SCY/K fed
	Season 1							
P_1	122.31	8.84	12.44	1.82	21.03	7.03	34.04	5.74
P_2	120.50	10.5	16.19	2.05	30.86	7.09	35.02	7.10
P3	120.41	9.24	15.63	2.00	29.63	7.07	34.22	6.66
LSD	Ns	0.76	0.74	0.19	1.77	Ns	0.81	0.34
CV	7.29	4.42	4.82	2.91	3.23	3.54	3.49	2.47
Solid	125.61	10.73	18.1	2.14	35.4	7.53	37.19	7.9
Performance percentage								
P_1	0.97	0.82	0.68	0.85	0.69	0.93	0.92	0.72
P_2	0.96	0.98	0.89	0.96	0.87	0.94	0.94	0.89
P3	0.96	0.86	0.81	0.93	0.84	0.94	0.92	0.84
Season 2								
P_1	124.07	7.68	13.8	1.84	26.00	7.25	34.49	5.42
P_2	123.08	9.56	16.41	2.12	35.43	7.59	35.38	7.06
P3	124.68	6.23	15.09	1.9	29.34	7.45	34.95	6.57
LSD	Ns	0.57	0.85	0.3	1.68	Ns	0.76	0.19
CV%	8.09	2.82	3.29	2.61	2.6	2.81	3.37	2.71
Solid	127.55	10.3	18.77	2.21	38.11	8.22	38.3	7.33
Performance percentage								
P_1	0.97	0.75	0.74	0.83	0.68	0.88	0.90	0.74
P_2	0.96	0.93	0.87	0.96	0.93	0.92	0.92	0.96
P3	0.98	0.60	0.80	0.86	0.78	0.91	0.91	0.90

This reduction, revealing that cotton growth and yield traits were slightly affected by relaying cotton on wheat compared to the case of late planting cotton in May after wheat, *i.e.*, the pattern 1. This tendency may be due to the fact that cotton plants have the potential to build up good shallow rootlets which are the main portion responsible for nutrient uptake. The high yield of P_2 over P_3 seemed likely due to the large distance between plants in that make cotton plants unable to capture all available solar radiation later in the season. Production is significantly in the late planting pattern (P_1).

However, yield reduction of 28% and 26% of the variety G85 cotton variety planted in P_1 compared to the regular cotton panting still from point of view not and if you don't have another choice except this repulsive late planting of Egyptian cotton genotypes. This also suggests that Egyptian cotton of barb dense (Abou-EL-Zahab *et al.*, 1998) as well as worldwide Barbadians germplasm (Abd alla *et al.*, 1999 and 2001) may have a potential to tolerate late planting the quality of lint under P_1 conditions, however, still warrant of further investigation.

Data in Table 3, also, revealed that the traits of monoculture (solid) cotton planting surpassed all traits in the tow intercropping patterns. This superiority in almost all growth and yield treats indicate two things, first the growth of cotton seedlings in the overlapping time of intercropping was suppressed due to competitive effects between cotton and wheat for nutrients, water and solar radiation in the early growth stages of cotton second the dray matter accumulation through the course of cotton life in intercrops sometime delayed (overlapping time) in intercrops compared to solid planting similar finding findings were obtained by Hussein (2006) and Zhang *et al.* (2007), however stated that seed cotton yield/feddan did not significantly different when cotton plants were sown solid or intercropped with wheat on march 25th.

Nitrogen levels and source

It has been known that the N management of intercropping systems rather than of mono-cropping should be improved by means of sustainable management of proper orientation of N supply and source . This part of the study, therefore was designed to study response of what plants to levels of nitrogen in Tables 4 and 5 indicated that the studied treats of both wheat and cotton were significantly affected by nitrogen data showed that yield and its components of cotton and wheat on pattern 2 over N levels were the highest values, whereas the lowest values were obtained when cotton was intercropped in pattern 1. The plants of no fertilization were the shortest, meanwhile the treatment 70 kg mineral N + 500g cerialein were the second best performance after solid case for the majority of the studied traits. The effect of nitrogen fertilization revealed significant yield and its attributes increasing proportional with increasing N levels.

TABLE 4. Effect of minerals and bio-fertilizer treatments on growth , yield and yield components of cotton during 2009/2010 and 2010/2011 seasons.

N-Fertilizer treatments	PH (cm)	NFB/ plant	NOB/ plant	BW/ gm	SCY/ plant (gm)	SI	Lint %	SCY/ K f
	Season 1							
Without fertilizer	107.7	6.80	10.67	1.62	17.29	5.8	35.09	4.71
500g Cerialine	109.62	7.63	12.34	1.83	22.7	6.49	35.45	5.47
70 kg mineral N	110.24	10.00	15.92	1.93	30.95	7.13	35.17	7.02
70 kg mineral N +500g	126.55	10.78	17.07	2.03	38.86	8.72	35.39	7.35
70 kg mineral N	134.27	11.06	19.43	2.14	39.73	8.92	35.17	7.50
LSD at 5 %	9.62	0.41	0.27	0.12	0.37	0.14	0.32	0.19
CV %	8.29	4.40	4.82	2.91	3.23	3.54	3.49	2.47
Soild	125.61	10.73	18.1	2.14	35.4	7.53	37.19	7.90
	Season 2							
Without fertilizer	114.88	6.56	10.79	1.59	17.16	5.96	34.89	4.56
500g Cerialine	106.58	7.29	12.41	1.85	23.08	6.58	34.47	5.50
70 kg mineral N	123.13	9.73	15.72	2.02	31.35	7.54	34.98	6.94
70 kg mineral N +500g	133.49	10.61	17.10	2.32	39.36	8.09	35.49	7.50
70 kg mineral N	141.63	10.09	18.49	2.22	40.39	8.98	35.86	7.58
LSD at 5 %	11.04	0.57	0.33	0.19	0.92	0.29	0.26	0.14
CV %	13.09	2.82	3.29	2.61	4.18	2.81	3.37	2.71
Soild	127.55	10.3	18.77	2.21	38.11	8.22	38.3	7.33

TABLE 5. Effect of minerals and bio-fertilizer treatments on growth, yield and yield components of wheat during 2009/2010 and 2010/2011 seasons.

N-fertilizer treatments	Plant height (cm)	No of spike	Spike length (cm)	No.of spikelet/ spike	Weight of spike(g)	No of grain/ spike	Seed Index (g)	Yield (ardab/ fed)	Straw (ton/ fed)	Protein (kg/ fed)
Season 1										
Without fertilizer	87.82	325.84	11.62	18.23	2.08	48.27	39.89	18.65	3.96	196.19
500g Cerialine	91.22	352.61	10.65	18.43	2.27	49.51	43.34	20.47	4.44	208.22
70 kg mineral N	93.46	381.26	11.40	18.67	2.39	52.63	46.36	21.89	4.88	217.18
70 kg mineral N +500g	96.50	398.08	11.78n	18.81	2.58	55.40	46.92	22.60	4.97	238.99
70 kg mineral N	96.03	400.88	11.96	18.88	2.65	55.71	47.03	22.72	5.07	237.68
LSD at 5 %	0.59	2.84	0.54	0.35	0.39	0.19	0.30	0.11	0.13	12.87
CV %	3.74	5.81	4.88	2.20	2.72	3.60	3.15	3.38	3.65	8.17
Soild	96.17	380.35	12.24	18.83	2.69	59.40	53.22	22.9	5.14	240.20
Season 2										
Without fertilizer	80.16	333.55	10.65	18.15	2.11	49.24	40.31	18.93	3.93	206.31
500g Cerialine	89.86	358.04	11.64	18.39	2.31	52.28	44.20	20.79	4.34	233.44
70 kg mineral N	93.32	391.11	12.00	18.57	2.44	55.63	47.29	22.44	4.72	250.97
70 kg mineral N +500g	95.49	417.53	12.19	18.70	2.64	59.41	48.06	22.87	4.93	263.77
70 kg mineral N	96.32	420.30	12.33	18.80	2.75	59.73	48.28	23.29	5.04	275.16
LSD at 5 %	7.12	3.78	0.19	0.14	0.29	0.36	0.18	0.69	0.18	8.58
CV %	4.5	6.86	3.60	3.32	2.51	3.69	3.41	3.50	2.14	6.63
Solid	97.25	415.1	12.37	18.84	2.77	65.08	58.14	23.15	5.11	265.07

For both seasons, there were no clear cut significant differences among each of the treatments 70 kg mineral N+ 500g cerialine, 75 kg mineral N (the recommended treatment) and solid cotton .The insignificance difference between the treatment 70 kg mineral N+ 500g cerialine and the recommended 75 kg mineral nitrogen in both seasons indicating that we can exploit the treatment 70kg mineral N+ 500g. This will help reducing the amount of mineral nitrogen added to wheat and cotton and so breathe a healthy life into growing environment.

The increase in plant height proportionally with N fertilization most likely back to the favorable effect of nitrogen in the metabolic processes and physiological activities of epistemic tissues, which responsible for cell division and elongation in addition to formation in plant organs (Zhang *et al.,* 2008 and Milroy & Binge, 2003). Moreover, Mekhemar (2008) showed that the significant increase in the total grain weight associated with high bio-N fertilizer rate added to wheat plants due to promoting grains filling by increasing photosynthetic productivity that boost the rate of dry matter accumulation in the grains.

Interaction

This part of the study was intended for exhibiting a level of a logic comparison among current planting patterns, nitrogen levels and data of traditional planting of both cotton and wheat through looking at the interactions among these treatments.

TABLE 6. Interaction effects between the planting pattern and nitrogen fertilizer on some wheat characters during 2009/2010 and 2010/2011 seasons.

Cropping Pattern	N-fertilizer	No of spikes/ m^2		No. of grains/spike		Weight of grains/spike (g)		Seed index (g)		Grain yield (ardab/fed)	
		2009/10	2010/11	2009/10	2010/11	2009/10	2010/11	2009/10	2010/11	2009/10	2010/11
P_1	Without fertilizer	321.02	326.49	49.23	47.83	2.01	2.08	39.25	39.9	18.37	18.51
	Cerialine	348.8	352.67	47.56	50.57	2.13	2.21	41.42	43.47	20.14	20.38
	70 kg mineral N	375.03	384.36	49.99	51.90	2.23	2.29	44.48	45.90	21.20	21.59
	70 kg mineral N +500g cerialine	386.09	393.78	52.4	54.54	2.37	2.41	45.00	46.57	21.74	22.26
	75 kg mineral N	391.44	404.13	52.84	54.88	2.43	2.53	45.28	46.94	22.08	22.56
P_2	Without fertilizer	332.27	340.98	47.46	50.74	2.14	2.18	40.56	40.95	18.94	19.28
	Cerialine	357.05	363.26	51.62	53.81	2.45	2.49	45.07	45.25	20.84	21.20
	70 kg mineral N	387.84	401.85	56.09	58.32	2.61	2.64	47.83	48.86	23.03	23.46
	70 kg mineral N +500g	405.08	424.08	59.13	62.38	2.81	2.94	48.64	49.52	23.31	23.81
	75 kg mineral N	415.67	439.95	59.44	62.60	2.87	3.04	49.02	50.05	23.66	24.24
P_3	Without fertilizer	324.22	333.17	48.12	49.14	2.10	2.08	39.87	40.09	18.65	19.00
	Cerialine	351.98	358.19	49.36	52.47	2.22	2.24	43.54	43.88	20.42	20.78
	70 kg mineral N	380.92	387.11	51.81	56.68	2.34	2.38	4.77	47.12	21.45	22.26
	70 kg mineral N +500g	391.07	404.72	54.67	61.29	2.55	2.58	47.11	47.50	21.95	22.54
	75 kg mineral N	395.52	422.79	54.84	62.04	2.62	2.67	47.38	47.86	22.43	23.06
LSD at 5 %^		4.93	6.55	3.25	0.62	0.17	0.13	3.40	1.11	0.18	0.48

Data in Table 6 showed a significant interaction between cropping patterns and nitrogen levels both of the two seasons are presented in Tables 7 and 8. Yield components traits and grain yield plant recorded the highest values by cropping P_2 and 75 kg nitrogen followed by P2 and 70 kg +500gm cerialine with very minor differences between them. The highest values of fruiting branches/ plant, seed index, no of plants at harvest seed cotton yield/plant and fed were obtained when cotton plants were sawn sole or intercropping with wheat I pattern 2 at nitrogen fertilization levels 75 kg N/fed (Table 8). The lowest values of these characters were obtained when cotton plants were sown late on May after wheat harvesting where there were no significant differences between the two treatments of nitrogen levels 70+ 500gm cerialine and the recommended treatment of 75 kg mineral nitrogen. The yield increase by raising minerals and Bio-N fertilizer levels or when cotton sown in pattern 2 may be due to increase in nutrient uptake when relaying cotton on wheat.

TABLE 7. Interaction effects between the planting pattern and nitrogen fertilizer on some cotton characters during 2009/2010 and 2010/2011 seasons.

Cropping pattern	N-fertilizer	N O B/plant		S I		SCY/plant (gm)		SCY/K/fed	
		2009/ 10	2010/ 11	2009/ 10	2010/ 11	2009/ 10	2010/ 11	2009/ 10	2010/11
P_1	Without fertilizer	10.44	10.69	5.63	5.82	15.85	15.40	4.47	4.41
	Cerialine	10.93	11.21	6.45	6.48	19.21	19.50	5.13	5.15
	70 kg mineral N	12.51	12.79	6.83	7.26	22.97	23.96	6.70	6.60
	70 kg mineral N +500 gceriali	14.87	15.54	7.56	7.74	29.14	31.29	7.17	7.09
	75 kg mineral N	18.44	18.78	8.68	8.94	29.14	39.81	7.78	7.75
P_2	Without fertilizer	10.86	10.94	6.09	6.14	37.98	19.72	4.68	4.67
	Cerialine	13.48	13.71	6.63	6.75	19.51	27.78	5.74	5.85
	70 kg mineral N	18.04	18.25	7.62	7.67	26.44	39.04	7.25	7.05
	70 kg mineral N +500g Cerialine	18.41	18.70	8.07	8.30	36.98	41.99	7.74	7.77
	75 kg mineral N	20.16	20.44	9.17	9.08	39.71	48.62	8.16	7.97
P_3	Without fertilizer	10.70	10.74	15.68	5.93	46.66	16.36	4.98	4.60
	Cerialine	12.61	12.30	6.38	6.52	16.52	21.95	5.55	5.52
	70 kg mineral N	17.22	16.12	6.94	7.68	22.44	31.05	7.12	7.17
	70 kg mineral N +500g Cerialine	17.92	17.05	7.43	8.22	32.91 35.72	35.80	7.59	7.65
	75 kg mineral N	19.70	19.26	8.91	8.92	40.56	41.72	8.05	7.93
LSD at 5 %^		0.45	0.57	0.31	0.22	0.37	1.59	0.27	0.33

This can be interpreted the fact that Bacterial populations inoculated to wheat grains helped in greater fixation of N at morphemic nitrogen. Plant N uptake is co-regulated by soil N supply and related to dry matter accumulation (Sainju *et al.*, 2005 and Lemaire *et al.*, 2007). Wheat crop as a component of relay intercropping system shard the cotton plants the same area for about 1.5 months. This period occupied the first growth stage of cotton (seedling and early branching stage). Thus, intercropping decreasing the N uptake of cotton seedlings during the intercropping period, after wheat harvesting, cotton plants compensate with extra N uptake at the subsequent growth stage, the nitrogen uptake is totally devoted to cotton plants and increasing the availability of reasonable amount of nitrogen for cotton plants and thus enhancing the vegetative growth of cotton (Zhang *et al.*, 2008). Moreover, when inoculating wheat with such organic fertilizer, it can afford a continuous supply of nitrogen fixed to the following crops, improve organic matter and reduce the needed amount of mineral nitrogen. If this is the case, besides the insignificance between the two treatment 70 + 500 gm and 75kg N, the current cropping patterns of relay intercropping is better for sustaining our environment by reducing the added amount of mineral nitrogen. Furthermore, sustaining the area devoted to planting the two major crops when length of the season will not allow double cropping , since these relay system allow cotton to be established from 4 to 6 weeks earlier than a similar yield – reduce double cropping pattern.

TABLE 8. Competition indices as affected by cropping patterns and fertilizer treatments.

Cropping pattern	N-fertilizer	Land Equivalent Ratio (LER)						Aggressively (Agg)			
		LW	LW	LC	LC	LER		A/W	A/W	A/C	A/C
		2009/10	2010/11	2009/10	2010/11	2009/10	2010/11	2009/10	2010/11	2009/10	2010/11
P_1	Without fertilizer	0.80	0.80	0.57	0.60	1.37	1.40	0.04	0.01	-0.04	-0.01
	Cerialine	0.88	0.88	0.65	0.70	1.53	1.58	0.05	0.01	-0.05	-0.01
	70 kg mineral N	0.93	0.93	0.85	0.90	1.77	1.83	0.05	0.01	-0.05	-0.01
	70 kg mineral N +500g cerialine	0.95	0.96	0.91	0.97	1.86	1.93	0.05	0.01	-0.05	-0.01
	75 kg mineral N	0.96	0.97	0.98	1.06	1.95	2.03	0.06	0.01	-0.06	0.01-
	avarge	0.90	0.91	0.79	0.85	1.70	1.76	0.05	0.01	-0.05	-0.01
P_2	Without fertilizer	0.83	0.83	0.59	0.64	1.42	1.47	0.02	0.02	-0.02	-0.02
	Cerialine	0.91	0.92	0.73	0.80	1.64	1.71	0.03	0.02	-0.03	-0.02
	70 kg mineral N	1.01	1.01	0.92	0.96	1.92	1.98	0.03	0.02	-0.03	-0.02
	70 kg mineral N +500g cerialine	1.02	1.03	0.98	1.06	2.00	2.09	0.03	0.02	-0.03	-0.02
	75 kg mineral N	1.05	1.05	1.03	1.09	2.09	2.13	0.03	0.02	-0.03	-0.02
	avarge	0.96	0.97	0.85	0.91	1.81	1.88	0.03	0.02	-0.03	-0.02
P_3	Without fertilizer	0.81	0.82	0.63	0.63	1.44	1.45	0.01	0.03	-0.01	-0.03
	Cerialine	0.89	0.90	0.70	0.75	1.59	1.65	0.01	0.04	-0.01	-0.04
	70 kg mineral N	0.94	0.96	0.96	0.98	1.90	1.94	0.01	0.04	-0.01	-0.04
	70 kg mineral N +500g cerialine	0.96	0.97	0.96	1.04	1.92	2.02	0.01	0.04	-0.01	-0.04
	75 kg mineral N	0.98	1.00	1.02	1.08	2.00	2.08	0.01	0.05	-0.01	-0.05
	avarge	0.92	0.93	0.85	0.90	1.77	1.83	0.01	0.04	-0.01	-0.04

Cropping pattern	N-fertilizer	Relative crowding coefficient (K)						Monetary advantage index (MAI)	
		KW	KW	KC	KC	K	K	MAI	
		09/10	10/11	09/10	10/11	09/10	10/11	09/10	10/11
P_1	Without fertilizer	4.60	5.41	2.71	3.90	12.48	21.07	1851.9	1956.1
	Cerialine	5.05	5.95	3.11	4.55	15.70	27.09	2384.8	2744.8
	70 kg mineral N	5.31	6.30	4.06	5.83	21.59	36.78	3892.5	4095.4
	70 kg mineral N +500g cerialine	5.45	6.50	4.35	6.27	23.69	40.74	4335.4	4492.3
	75 kg mineral N	5.53	6.59	4.72	6.85	26.11	45.13	4802.2	5042.4
	avarge	5.19	6.15	3.79	5.48	19.67	33.70	3453.4	3666.2
P_2	Without fertilizer	9.11	9.17	4.50	3.07	41.03	28.15	2223.2	2296.4
	Cerialine	10.03	10.08	5.52	3.85	55.37	38.77	3210.9	3478.3
	70 kg mineral N	11.08	11.15	6.98	4.64	77.28	51.70	4648.4	4779.8
	70 kg mineral N +500g cerialine	11.21	11.32	7.45	5.11	83.51	57.83	5044.3	5326.8
	75 kg mineral N	11.62	11.53	7.85	5.24	91.24	60.39	5446.8	5537.7
	avarge	10.61	10.65	6.46	4.38	68.54	46.65	4114.7	4283.8
P_3	Without fertilizer	5.01	5.24	3.96	6.05	19.86	31.69	2217.7	2196.2
	Cerialine	5.49	5.73	4.41	7.25	24.23	41.60	2973.1	3178.2
	70 kg mineral N	5.77	6.14	6.04	9.42	34.81	57.88	4596.7	4596.1
	70 kg mineral N +500g cerialine	5.90	6.22	6.04	10.05	35.62	62.53	4649.1	4982.1
	75 kg mineral N	6.03	6.36	6.40	10.42	38.60	66.31	5055.9	5277.3
	avarge	5.64	5.94	5.37	8.64	30.29	51.32	3898.5	4045.9

Competition indices

Bio-economic efficiency of the different cotton based cropping patterns. Different competition indices with such relay intercropping pattern were assessed and can be discussed as follow:

First, Land equivalent ratio (LER) was used as a criterion for measuring efficiency of intercropping advantage by comparing the intercropped area with mono-cropping (Mead & Willey, 1980). Data presented in Table 8 pointed out the averaged values of LER ratios over cropping patterns and N-fertilizer treatments were greater than unity indicating the intercropping gave advantages in land use which means the actual productivity was higher than expected. The advantage of both crops from intercropping patterns was clear since the partial LER of both cotton and wheat was exceeded 0.5. The total LER estimates averaged over patterns and N –fertilizer showed increasing the efficiency of land use by 70%, 81% and 77% in the first year and by 76, 88 and 83% in the second year. This part of the study is reporting the sustainability over time and space through comparison second year. The lower LER was in part due to a low relative yield of cotton. Increasing LER indicating an advantage of intercropping over sole system in terms of environment sustainability because of the efficient use of environmental resources like plant canopy, species compatibility and less competition that reflected in increase total yields of both crops. Such similar advantages attained by Hussein (2006) and Zhang *et al.* (2007) showed that LER of intercrops differed significantly among cropping patterns and reported wheat and cotton relay intercropping systems do have a substantial yield advantages in dray mass compared to single crop systems. Results in Table 8, also, indicated that average of 76% and 82% of areas would be required by a sole cropping system to recover the collective yield of the two intercropped crops for first and second year, respectively. Second, relative crowding coefficient (RCC or K) is the measure of relative dominance of one species over the other in intercropping (Dewit, 1960). When the product of tow coefficients (K wheat x K cotton) is greater than one, there is a yield advantage, if the value of K is one there is no yield advantage and if less than one there is no yield advantage and the system has disadvantage (Khan *et al.*, 2001). Average values of wheat (KW) exceeded those of cotton indicating that wheat was good competitor and the dominant component, whereas cotton was the dominated (Table 8). Results on the relative crowding coefficient (K) showed higher values more than unity for the cropping patterns and N-fertilizers with the maximum of P_2 (68.54 and 46.65) in the two years. This was indicated the clear-cut yield advantage due to intercropping and the superiority of pattern 2.

Third, aggressively (A) indicates the relative yield increase in "a" crop is greater than of "b" crop in an intercropping system (Mc-Gilchrist, 1965) if the value of A is zero, both crops are equal. If the value of A is positive for a crop "a" then "a" crop is dominant over the other and vice versa. Aggressively results presented in Table 8 showed very low competitive abilities for any of intercropping pattern indicating that the intra-specific competition is stronger than inter–specific one. On the other hand, the data on the aggressively were lower than unity. Values for wheat were positive (dominant), whereas, values for cotton were negative (dominated) in the three cropping patterns.

Monetary advantage index (MAI)

Salts totally revealed a substantial difference between the monetary advantage index(MAI) produced by traditional planting late planting (P_1) and the relaying patterns P_2 and P3 it supported the superiority of P_2 over the other two patterns has intensive pattern reached the highest mean MAI due to higher production of both intercropped species from the unit over the velar was highest with P_2 (Table 9). In other words, the component crops yields of cotton are lower in relay intercropping patterns than in a conventionally mono-cropping (solid), but the cumulative yield of the cotton-wheat intercropping is greater than of monocultures. Data presented in Table 8 indicated that the advantage of intercropping wheat patterns and cotton expresser in terms of the farmer. The MAI, is an indicator of the economic feasibility of intercropping system .These values were positive due to intercropping cotton with wheat , the highest MAI value (5446.8 and 5537.7 LE) was observed by P_2 and adding 75 kg mineral N in both seasons , respectively , while the lowest values were observed when intercropping pattern P_1 and without fertilizer (1851.9 and 1956.1 LE) in both seasons , respectively. Similar results were recorded by Hussein (2006).

TABLE 9. Total income of wheat and cotton as advantages of intercropping pattern during 2009/2010 and 2010/2011 seasons.

Treatment	N-fertilizer	Total income LE					
		2009/2010			2010/2011		
		Wheat	Cotton	Total	Wheat	Cotton	Total
P_1	Without fertilizer	3857.7	2999.4	6857.1	3887.1	2959.1	6846.2
	Cerialine	4229.4	3442.2	7671.6	4279.8	3455.7	7735.5
	70 kg mineral N	4452.0	4495.7	8947.7	4533.9	4428.6	8962.5
	70 kg mineral N +500g cerialine	456.4	4811.1	9376.5	4674.6	4757.4	9732
	75 kg mineral N	4636.8	5220.4	9857.2	4737.6	5200.3	9937.9
P_2	Without fertilizer	3977.4	314.3	7117.7	4048.8	3133.6	7182.4
	Cerialine	4376.4	3851.5	8227.9	4452.0	3925.4	8337.4
	70 kg mineral N	4836.3	4864.8	9701.1	4926.6	4730.6	9657.2
	70 kg mineral N +500g Cerialine	4895.1	5193.5	10088.6	5000.1	5213.7	10213.8
	75 kg mineral N	4968.6	5475.4	10444.4	5090.4	5347.9	10438.3
P_3	Without fertilizer	3916.5	3341.6	7258.1	3990.0	3086.6	7076.6
	Cerialine	4288.2	3724.1	81012.3	4363.8	3703.9	8067.7
	70 kg mineral N	4504.5	4777.5	9282	4674.6	4811.1	4485.7
	70 kg mineral N +500g Cerialine	4609.5	5092.9	9702.4	4733.4	5133.15	9866.5
	75 kg mineral N	4710.3	5401.6	10111.9	4842.6	5321.0	10163.6
Wheat alone		4809.0	………	4809.0	4861.5	……....	4861.5
Cotton alone		………	5300.9	5300.9	………..	4918.43	4918.43

Economic evaluation

This part of research is special attention to social acceptance and money profit that persuade crops grower to implement this type of cropping sustainability over gross and net profit intended in this section can be attained through assessing the best cropping patterns for resources management by calculating the economic values of relay intercropping thus current late planting P_1 and the two P_2 and P3 relay cropping patterns were checked against the traditional (solid) planting system using shown in Table 9. The evaluation of different intercropping pattern of cotton with wheat was made for the two seasons as a total income of the two components and compared with each of them as a solid crop due to market price. Using intercropping pattern of P_2 gave the highest values (10444.4 LE and 10438.3 LE) in first and second season ,respectively , while the lowest values were observed when intercropping pattern P_1 and without fertilizer (6857.1 LE. and 6846.2 LE) both seasons , respectively. These results are in agreement with those obtained by Sherif *et al.* (2011).

In conclusion the current study enhanced the sustainability dimensions including social acceptance, environmental health and economic benefits. Cotton based relay intercropping with wheat seems a promising strategy for solving the problems of sustaining Egyptian cottons production and avoid the problem of growth overlapping of these two major crops.

Thus, relay intercropping cotton on wheat can be recommended as an intensive cropping system for gaining two economic main yields from the two long duration crops without significant reduction in wheat and reasonable cotton production besides maintaining environment health .

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التحميل المناوب للقطن مع القمح تحت مستويات مختلفة من التسميد النتروجينى

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المحافظة على زراعة القطن المصري في التركيب المحصولي له أهمية كبيرة للمزارع المصري والسياسية الزراعية وكذا باحثي بحوث القطن فقد أجري هذا البحث في محطة بحوث سرس الليان في محافظة المنوفية خلال موسمي ٢٠١٠/٢٠٠٩ و٢٠١١/٢٠١٠ لدراسة التحميل المناوب للقطن مع القمح ومقارنته بالزراعة المنفردة وتناولت الدراسة تأثير ثلاثة أنظمة من التحميل المناوب للقطن صنف جيزة ٨٥ على القمح صنف سخا ٩٣ بالمقارنة مع الزراعة المنفردة على النمو وصفات المحصول والمحصول كما تتضمن الدراسة تأثير ثلاث صور ومستويات من النتروجين على الصفات المذكورة ودرست العلاقات التنافسية وأنظمة التحميل وكذا الدالات الأقتصادية تحت تأثير هذه العوامل في الأنظمة المختلفة. وتظهر النتائج أن الثلاث أنظمة للتحليل المناوب اختلافات في الصفات المدروسة بين سنتي الدراسة والتفاعلات بين السنوات و الأنظمة المدروسة. وقد أظهرت النتائج أن تأثير عام وواضح لتفوق نظام المصاطب على ٩٠ سم (P_2) المحصولي وصفاته لكل من القطن و القمح بالمقارنة بنظامي التحميل الآخرين. كما كان هناك اتجاه عام في النتائج يقدم ظهور أي فروق معنوية بين معاملة ٧٠ كيلو جرام من النيتروجين المعدني +٥٠٠جرام من السماد الحيوي السريالين وبين المعدل الموصى به وهو ٧٥ كيلو جرام من السماد النيتروجينى فقط في كلا الموسمين كما أظهر التفاعل بين نظم التحميل ومستويات النيتروجين أن نظام P_2 والمعاملة التي سمدت ب ٧٠ كيلو جرام من النيتروجين المعدني +٥٠٠جرام من السماد الحيوي والسريالين كانتا أفضل معاملتين لكلا المحصولين وكذا الحفاظ على البيئة وصحة الإنسان حيث تنقص كميات الأسمدة المعدنية في هذه الأنظمة . كما أظهرت دالات العلاقات التنافسية (تقديرات معدل استغلال الأرض ، معامل الحشد النسبي والعدوانية لأنظمة التحميل المختلفة مقارنة بالزراعات المنفردة لكلا المحصولين وكذا مدى تأثيرها بمعدل وصور التسميد النيتروجينى بمقدار ٨٢% ، ٧٦ في العام الأول والثانى على التوالي وذالك بسبب زيادة معدل الاستغلال للأرض ونقص من تكاليف الإنتاج. كما جاءت اعلي قيمة للعائد النقدي الكلي والدليل النقدي من نظام التحميل الثاني P_2 والمسمد بـ٧٥ kg N/fed في كلا الموسمين على التوالي.