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Effect of Reducing Mineral Nitrogen and Phosphorus Fertilizer by Foliar Spraying of Phosphorus and Bio-Fertilization on Quality and Quantity of Cotton

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ABSTRACT

Two field experiments were conducted at the Experimental farm of Sids Agriculture Research Station, ARC, Beni-Suef Governorate to investigate the possibility of reducing the recommended rate of mineral nitrogen (NRR) and phosphorus (PRR) fertilizers by using monoammonium phosphate (MAP) as 1% foliar spraying twice or biofertilizer and its effect on quality and quantity of cotton (Gossypium barbadense, Giza 95 variety). The results show that increasing nitrogen, phosphorus and added bio-fertilizer were significantly increased growth parameters, except first fruiting node, yield and yield components and seed index of cotton, while lint percentage decreased. On the other hand, earliness percentage was negatively responded to nitrogen levels and positively to phosphorus and bio-fertilizer. The studied treatments were not affected fiber properties. Combined 75% NRR+1% foliar spraying of MAP twice or using bio-fertilizer gave similar effect on quality and quantity of cotton, equal to that under 100 % NRR and100 %PRR, which means the possibility to save about 25 % from recommended rate of nitrogen and phosphorus by foliar spraying of phosphorus or bio-fertilizer.

Keywords: Cotton, nitrogen, phosphorus, bio-fertilizer, growth, yield and yield components and fiber properties.

INTRODUTION

Egyptian cotton (Gossypium barbadense L.) is the most important crop, it has potential source for plant protein after soybeen and oil after soybeen, palm-tree, colza and sunflower (Sawan *et al*, 2006). It called as "white Gold" for its importance as a commercial fiber crop. The fiber of Egyptian cotton has a good quality for its fine and excellent propeties, which resulted in softer and stronger at the same time (Mehasen, *et al*, 2012).

Nitrogen is an important macro-nutrient for growth and development. It combine with C, H.O and some times sulphur to form amino acids, amino enzymes, nucleic acids, chlorophyll, alkaloids and purine bases (Jones *et al*, 1991). Supplying the cotton plant with adequate N dose during the growth will produce healthy leaves with the photosynthetic capacity needed to support the growth and reproductive components (Bondada and Oosterhuis, 2001 and Zhang *et al*, 2002). However, providing inadequate N will resulted in slower stop leaf development (Ali, 2015). But surplus N enhances excessive vegetative growth, resulting poor boll set due to vegetative shading, lodging, insect attack and increase in maturity (Walker *et al*, 2001).

Phosphorus is second important macronutrient after nitrogen, since it involved with many vital physiological, metabolic and biochemical functions like utilization of sugars and starch, cell divition, photosynthesis and fat and albumin formation. The deficiency of P resulted in limits of roots and shoot growth, consequently reduce the yield, while application adequate P improved growth and yield (Abd El-Gayed and Abd El-Hafeez 2014). Rakocevic *et al* (2017) indicated that using monoammonium phosphate as P fertilizer increased plant growth comparing with triple-superphosphate fertilizer, meanwhile it decreased the environmental pollution.

Bio-fertilizer is considered a renewable source of plant nutrients substituting chemical fertilizes in sustainable agricultural system. Also, it considers to be low cost and eco-friendly source. It refer to microorganisms, which increase plant growth, nitrogen fixation, yielding growth promoting as hormonal substances and increasing nutrients availability in soil (Hedge *et al*, 1999). Many authors reported the beneficial effect of bio-fertilizers on quality and quantity of cotton such as Ibrahim and Omar (2014) and Zewail and Ahmed (2015).

The objective of this study is to investigate the possibility of reducing mineral nitrogen and phosphorus fertilizes by foliar spraying of monoammonium phosphate and bio-fertilization and its effect on quality and quantity of cotton growth under alluvial soil in Middle Egypt conditions.

MATERIALS AND METHODS

This investigation was conducted at Sids Agricultural Research Station, ARC, Egypt during the two successive seasons of 2017 and 2018 to study the effect of different levels of nitrogen (50, 75 and 100 % from its recommended rate, NRR); different phosphorus sources and levels (superphosphate, SP(6.8 % P) at rate of 25, 50 and

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100 % PRR, foliar spraying of 1 % monoammonium phosphate, MAP (11 % N and 24 % P twice after first irrigation and one month later; and bio-fertilization (with and without) as well as their interactions on quality and quantity of Giza 95 cotton variety. The experimental soil was clay in texture, having 8.1 and 8.0 ; 1.4 and 1.6 ;2.1 and 2.3 % ;21.3 and 22.5 ppm ; 10.1 and 10.4 ppm ; and 175 and 181 ppm of pH, EC, soil organic matter and soil available N, P and K in both seasons, respectively (according to A.O.A.C (1980). The experiment was laid out a complete randomized block in four replication. Cotton seeds were received from Cotton Research Institute and were sown on 2nd and 6th April in the two growing seasons, respectively in plots (12 m2). The seedlings were thinned to two plants per hill. Nitrogen fertilizer treatments (as ammonium nitrate, 33.5 % N) were added in two equal doses, before the first and second irrigation, respectively, while superphosphate treatments were applied before planting during land preparation. The bio-fertilizer, namely Nitrobein (proved from Micro. Dept. Soil, Water and Environment, ARC, Egypt) were inoculated the cotton seeds directly before sowing. Other cultural recommended practices for growing cotton were done as indistrict. During the harvest, ten representative plants were randomly taken to determine plant height, first fruiting node, number of fruiting branches/plant, earliness %, number of open bolls/plant, boll weight (g), seed cotton yield (ken/fed), lint % and seed index. Also, some fiber properties, e.g., micronair reading and pressly index were determined for representative samples at Laboratories of Cotton Research Institute according to A.S.T.M. (1979).

All obtained results were exposed to the statistical analysis according to Snedecor and Cochran (1980). The means were compared through L.S.D. at 5 % test of probability.

RESULTS AND DISCUSSION

Growth parameters

It is evident from the data in Table (1) that the studied cotton growth parameters, namely, plant height, first fruiting node and number of fruiting branches/plant were significantly affected by nitrogen, phosphorus and bio-fertilization, except first fruiting node, which not affected. It is obvious to notice that increasing nitrogen level had a positive effect on plant height and number of fruiting branches/plant, which mainly due to nitrogen is a major macronutrients, consequently supplying cotton plant with nitrogen would allow the meristimatic system to more active caused in increasing the number and size of leaf cell, accordingly increased these parameters Thompsond and Troch (1975). On the other hand, first node did not respond to nitrogen levels. The results show that plant height and number of fruiting branches/plant were positively responded to increasing phosphorus levels from 25 % PRR to 100 % PRR in both seasons. Combined 50 % PRR with foliar spraying of MAP yielded plant height and number of fruiting branches/plant, statistically equal to those under 100 % PRR. In this concern, Mengel and Kirkby (1987) mentioned that phosphorus is essential elements for cell divition and development of meristimatic tissue. Using monoammonium phosphate as foliar spraying gave cotton growth equal to the effect of 50 % from PRR as superphosphate fertilizer. As for bio-fertilizer, the results clearly show that bio-fertilizer had a markedly positive effect on plant height and number of fruiting branches/plant. Under the same dose of mineral N and superphosphate, inoculated cotton seeds with bio-fertilizer yielded cotton growth greater than those without bio-fertilization. The beneficial effect of bio-fertilizer is mainly due to fixation of atmospheric N, produce adequate photohormones such as indoleacetic acid; gibberellins and cytokinins, enhancing the nutrients uptake and protecting the plant against pathogens through the production of intibacterial substances (Hauwaka, 2000). Similar results were obtained by Baraich *et al* (2012) and Seadh *et al* (2012) for nitrogen, Saleem *et al* (2011) and Abd El-Hady (2012) for phosphorus, and Marimuthu *et al* (2013) and Zewail and Ahmed (2015) for bio-fertilizer.

Table 1. Effect of nitrogen levels, phosphorus levels and sources, and bio-fertilization on growth parameters of cotton

Treatments	Plant height (cm)		first fruiting node		No. of fruiting branches/plant	
	2017	2018	2017	2018	2017	2018
100% N+100% SP	131.5	129.8	9.4	9.1	16.7	16.4
75% N+50% SP	129.0	127.0	9.3	9.0	15.2	15.1
75% N+50% SP+BF	131.2	129.4	9.0	8.9	16.6	16.5
75% N+50% SP+1% MAP	131.4	129.5	9.0	9.1	16.7	16.6
75% N+25% SP	126.3	125.4	9.1	9.1	13.8	13.6
75% N+25% SP+ BF	129.1	127.1	9.1	9.1	15.1	15.0
75% N+25% SP+1% MAP	129.2	129.1	9.5	91	15.0	15.1
50% N+50% SP	123.3	122.1	9.4	9.3	15.3	15.2
50% N+50% SP+BF	126.1	124.5	9.3	9.0	15.2	15.1
50% N+50% SP+1%MAP	126.3	124.8	9.2	9.1	16.5	16.3
50% N+25% SP	120.4	119.3	9.1	9.2	16.6	16.4
50% N+25% SP+ BF	122.5	121.6	9.3	9.3	14.0	13.9
50% N+25% SP+1% MAP	122.7	121.9	9.0	9.5	14.1	14.0
L.S.D. at 5%	1.36	1.23	NS	NS	0.92	0.90

SP = Superphosphate fertilizer. MAP = monoammonium phosphate fertilizer. BF = Bio-fertilizer.

Yield and yield components:

The data in Table (2) represent the effect of nitrogen, phosphorus and bio-fertilization as well as their interaction on yield and its components of cotton, i.e., number of open bolls/plant, boll weight and seed cotton yield. The data show that, regardless to phosphorus and bio-fertilizer, these parameters were significantly increased as nitrogen fertilizer increased from 50 to 100 % RR. The promotive effect of nitrogen on cotton yield and its components is mainly due to nitrogen is a constituent of most organic compounds, such as, amino and nuclic acids, enzymes, olkaloids, vitamins, phosphatides, purine and chlorophyll materials (Mengel and Kirkby, 1987). As for phosphorus fertilization, the results show that number of bolls/plant, boll weight and seed cotton yield were positively responded to increasing phosphorus level from 25 to 100 % RR. Moreover, foliar spraying of 1 % MAP twice in combined with 50 % PRR gave yield and yield components equal to those due to 100 % PRR.

Table 2. Effect of nitrogen levels, phosphorus levels and sources and bio-fertilization on yield and its components.

Treatments	No. of open bolls/plant		Boll weight (g)		Seed cotton yield (ken/fed)	
	2017	2018	2017	2018	2017	2018
100% N+100% SP	25.6	20.8	3.26	2.24	11.40	11.22
75% N+50% SP	24.5	19.8	3.11	3.09	11.12	11.01
75% N+50% SP+BF	25.3	20.6	3.25	3.24	11.38	11.29
75% N+50% SP+1% MAP	25.4	20.7	3.26	3.24	11.41	11.26
75% N+25% SP	22.3	17.5	3.06	3.24	10.03	10.01
75% N+25% SP+ BF	24.4	19.8	3.10	3.08	10.33	10.28
75% N+25% SP+1% MAP	24.5	19.8	3.10	3.09	10.35	10.29
50% N+50% SP	20.6	15.3	3.04	3.02	8.17	8.14
50% N+50% SP+BF	22.8	17.6	3.08	3.06	8.42	8.29
50% N+50% SP+1%MAP	22.7	17.6	3.07	3.06	8.44	8.30
50% N+25% SP	18.9	14.1	2.98	2.96	8.01	7.89
50% N+25% SP+ BF	20.5	16.2	3.01	3.00	8.36	8.13
50% N+25% SP+1% MAP	20.7	16.3	3.01	3.01	8.38	8.13
L.S.D. at 5%	1.03	1.01	0.03	0.02	0.09	0.08

SP = Superphosphate fertilizer. MAP = monoammonium phosphate fertilizer. BF = Bio-fertilizer.

The increment in these parameters caused by increasing phosphorus levels may be attributed to it is essential for photosynthesis, intercoversion of carbohydrates and related to amino acids and fat metabolism and biological processes like, conversion of sugar to starch and cellulose (Delvin and Witham, 1986).

On the other hand, the promotive effect of foliar spraying of MAP may be due to its high solubility and more activity to absorption by plant. Respecting to bio-fertilization, the data show that bio-fertilizer application significantly improved yield and yield components of cotton comparing with no bio-fertilization. The positive effect of bio-fertilizer on these parameters is mainly due to its effect on cotton growth as the abovementioned discussed in Table (1). As for the interaction between N,P and bio-fertilization, the results clearly indicate that combined foliar spraying of 1% MAP twice or bio-fertilizer with 75 % NRR+50 %PRR gave, statistically number of bolls/plant, boll weight and seed cotton yield equal to treatment of 100 % NRR+100%PRR. Abou-El-Nour *et al* (2000) mentioned that foliar application of phosphorus under nitrogen fertilization increased cotton yield and its components by increasing photosynthesis and plant metabolism and as an activator of some enzyme, consequently affect boll formation and stability. These results are in harmony with those obtained by Aslam *et al* (2013) and Singh (2015) for nitrogen, Saleem *et al* (2011) and Abd El-Gayed and Abd El-Hafeez (2014) for phosphorus and Ibrahim and Omar (2014) and Sarhan and Abd El-Gayed (2017) for bio-fertilizer.

Earlines %, lint %, seed index and folir properties:

The data in Table (3) show the response of earliness %, lint %, seed index and some fiber properties, namely micronair reading and pressly index to nitrogen, phosphorus and bio-fertilization. The results reveal that increasing nitrogen levels was significantly decreased earliness and lint percentage and increased seed index. The negative effect of nitrogen on earliness % may be due to the fact that the high N application resulted in increasing in cotton growth and yield components (Tables 1 and 2) which need more time to reach maturity, and the majority of bolls were gained at the second picking (Abou El-Nour *et al* (2001). These results are in accordance with the finding of El-Dobaby *et al* (1995) and Abd El-Malik and El-Shahawy (1999). The promotive effect of nitrogen on seed index may be due to addition of nitrogen improved photosynthetic activity, in turn higher accumulation of metabolitices in seeds (Abdallah, 1987). These results agree with those obtained by Abd El-Hady (2019). The reduction in lint percentage caused by increasing nitrogen levels can be explain by as nitrogen application increased seed index as mentioned before, accordingly decreased lint percentage. Similar results were obtained by El-Sayed and El-Menshawi (2005). Under the same level of nitrogen, increasing phosphorus as soil or foliarly application, or added bio-fertilizer enhanced earliness percentage. These results are in agreement with those obtained by a Elayan *et al* (2018) for phosphorus, and El-Shazly and Darwish (2001) and Galal (2003) for bio-fertilizer. On the other hand, fiber properties did not respond to nitrogen, phosphorus and bio-fertilization treatments, which may be due to these parameters are essentially genetically controlled. Similar results were obtained by Abd El-Hady (2019) for nitrogen, Abo-El-Nour et (2001) al for phosphorus and Abd El-Hady (2012) for bio-fertilizer. In general, earlier seed cotton yield and highest lint percentage achieved under the treatment of 50% NRR + 50% PRR + 1% foliar spraying of MAP + bio-fertilization. While, the plants received 100% NRR + 100% PRR recorded the heaviest seeds.

Table 3. Effect of nitrogen levels, phosphorus levels and sources and bio-fertilization on earliness %, lint %, seed index and some fiber properties.

Treatments	Earliness %		Lint %		Seed index (g)		Micronair reading		Pressly index	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
100% N+100% SP	92.25	91.42	39.82	39.92	11.55	11.46	4.5	4.6	9.0	9.1
75% N+50% SP	91.56	90.33	40.25	40.36	10.47	10.40	4.6	4.6	8.8	9.2
75% N+50% Sp+BF	92.30	91.06	40.01	40.13	11.51	11.42	4.5	4.5	8.7	8.9
75% N+50% SP+1% MAP	92.37	91.11	40.00	40.12	11.56	11.28	4.5	4.6	8.7	8.9
75% N+25% SP	89.15	88.33	40.68	40.80	10.03	10.00	4.5	4.6	9.1	8.7
75% N+25% SP+ BF	90.36	89.42	40.25	40.36	11.17	11.13	4.4	4.7	8.9	8.6
75% N+25% SP+1% MAP	90.32	98.45	40.24	40.35	11.16	11.14	4.6	4.6	8.7	8.7
50% N+50% SP	95.63	94.72	41.06	41.15	10.14	10.11	4.6	4.6	8.8	8.9
50% N+50% SP+BF	96.70	92.64	40.83	40.96	10.67	10.62	4.5	4.5	86	8.7
50% N+50% SP+1%MAP	96.13	95.36	40.86	40.97	10.65	10.63	4.5	4.5	8.7	8.9
50% N+25% Sp	94.06	93.13	41.52	41.65	9.95	9.91	4.6	4.5	8.7	8.9
50% N+25% SP+ BF	95.21	94.34	41.18	41.23	10.25	10.13	4.5	4.6	8.6	8.8
50% N+25% SP+1% MAP	95.28	94.32	41.16	41.24	10.28	10.13	4.6	4.6	8.9	8.7
L.S.D. at 5%	0.83	0.81	0.66	0.63	0.36	0.34	N.S	N.S	N.S	N.S

SP = Superphosphate fertilizer. MAP = monoammonium phosphate fertilizer. BF = Bio-fertilizer.

CONCLUSION

From the results of this research, it could be recommended to supply cotton plant with 75 % NRR+75 % PRR+ foliar spaying of 1% monoammonium phosphate twice or using bio-fertilizer to obtain best quality and quantity of cotton under Middle Egypt conditions.

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تأثير تقليل استخدام الأسمدة المعدنية للنيتروجين والفوسفور برش فوسفات الأمونيوم الأحادى أو استخدام السماد الحيوى على محصول القطن كما ونوعاً.

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أجريت تجربتان حقليتان بالمزرعة البحثية بمحطة بحوث سدس, مركز البحوث الزراعية, بنى سويف لدراسة إمكانية تقليل إستخدام الأسمدة المعدنية للنيتروجين والفوسفور برش فوسفات الأمونيوم الأحادى مرتان بمعدل 1 % او بإستخدام السماد الحيوى, وتأثيرهم على محصول القطن كما ونوعا. وقد أوضحت نتائج الدراسة على أن زيادة معدل النيتروجين والفوسفور وكذلك إضافة السماد الحيوى أدى إلى زيادة معنوية فى جميع صفات النمو (طول النبات وعدد الأفرع الثمرية) ما عدا أول عقدة ثمرية والتى لم تتأثر بالتسميد النيتروجينى والفوسفاتى, وكذلك صفات المحصول ومكوناتة ومعامل البذرة. اما نسبة التبكير فقد تأثرت سلبيا بزيادة التسميد النيتروجينى وايجابيا بزيادة التسميد الفوسفورى وإضافة التسميد الحيوى. وقد أدى زيادة التسميد النيتروجينى والفوسفاتى وإضافة التسميد الحيوى إلى تقليل نسبة تصافى الحليج. ولم يؤثر التسميد النيتروجينى والفوسفاتى والحيوى على الصفات التكنولوجية للألياف (متانة الألياف ونعومة الشعر). وقد اعطت معامله 75 % من الموصى به للنيتروجين والفوسفور + رش محلول فوسفات الأمونيوم الأحادى بمعدل 1 % مرتان أو إضافة السماد الحيوى أعلى قيم للصفات الخضرية والمحصول ومكوناتة مساوية احصائيا لمعاملة 100 % من الموصى بة للنيتروجين والفوسفور مما يشير إلى امكانية تقليل استخدام الأسمدة المعدنية للنيتروجين والفوسفور بمعدل 25 % برش فوسفات الأمونيوم الأحادى أو بإضافة السماد الحيوى.ومن نتائج الدراسة يمكن التوصية بتسميد نبات القطن بمعدل 75 % من الموصى به من الأسمدة النيتروجينية والفوسفاتية المعدنية مع الرش بمحلول 1 % مرتان من سماد فوسفات الأمونيوم الأحادى أو إضافة الأسمدة الحيوية بدون فقدان فى المحصول.