ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645
Indian Journal of Science and Technology, *Vol 11(5), DOI: 10.17485/ijst/2018/v11i5/115083, February 2018*

Impacts of Balanced Fertilization based on Soil Testing on Yield, Nutrients Uptake and Net Return of Irrigated Wheat Grown in Delta, Egypt

S.H.A Shaaban*, E. A. A. Abou El-Nour, and M. M. El-Fouly

Department of Fertilization Technology, National Research Centre, 33 El- Bohouth St., (former El- Tahrir St.,) Dokki, Giza, Postal Code: 12622, Egypt; shashaaban@yahoo.com, elzanatyabouelnour@gmail.com, mohelfouly@link.net

Abstract

Objectives: To investigate the effect of NPK doses calculated considering soil testing alone and/or in combination with spraying micronutrients on yield, nutrient uptake and net return of wheat plants. **Methods**: Experiments were carried out in the farmer's field in Kafer El Kadera village, El–Monofia governorate, Egypt, during winter seasons from 2009 to 2013 using wheat (var., Sakha, 93). Soil sample was taken before sowing every season to test physical and chemical properties. Six NPK combinations were tested + control. Fertilizers were applied to the soil at 30 days after sowing. Micronutrients used as a foliar application at 45 days after sowing using cheated micronutrient compound. Leaf samples were analyzed for nutrients. Yield and yield components were determined; Wheat nutrient contents and uptake were calculated in grains. Data were subjected to the analysis of variance of randomized complete block design. **Findings:** The results indicated that the NPK dose considering soil testing plus spraying of micronutrients, improved most of growth parameters, and enhanced nutrients uptake which induced significant increase in biological yield as compared to other treatments, where the average of increase reached 46%. The analysis of cost and return revealed that balanced fertilization was economically viable in NPK considering soil testing + micronutrients foliar spray. **Application/Improvements:** It could be concluded that 190, 143, 131 kg ha^{-1} N, P_2O_5 and K_2O was the suitable fertilizer doses combined with micronutrients as foliar application to obtain maximum and economic yield of wheat.

Keywords: Fertilization, Nutrients, Wheat, Yield

1. Introduction

Wheat is the most important cereal crops in Egypt, where wheat is used to overcome the growing consumption of food for humans and feed for animals. Egypt is still one of the largest importers of wheat. Statistics provided by the Ministry of Agriculture and Land Reclamation in 2016 showed that, wheat imports for the 2016/17 (July/June) are estimated at 11.5 million tones, about the same level as the last year and about 1 million higher than the average for the last five years. Wheat production in Egypt increased from 2.08 in 1983 to 7.37 million ton in 2011/2012. This increase was achieved by increasing wheat area from 0.769 to 1.336 million ha. /year and grain yield from 3.57 to 6.45 ton/ha.

**Author for correspondence*

Figures released by the Ministry of Agriculture and Land Reclamation in March 2016 showed a slight increase in the area planted to wheat (1.435 million hectares in 2015/16 compared to 1.418 million hectares in the previous year)[1]. At 9 million tones, wheat production is estimated to remain at the same level as the past year and the five year average (average 6.27 ton/ha).

As compared with the average world wheat productivity, the wheat productivity in Egypt is considered high where the average world wheat productivity, in 2010 was 3 t/ha for example, India has an average yield of 2.6 t ha^{-1} compared with 6.5 t ha^{-1} in Egypt[2].

This increase in productivity per hectare resulted in the loss of more soil nutrients. Adopted the cultivation of improved varieties, and less attention to running balanced nutrition. These factors are limiting of wheat production. New techniques of nutrient management are required to compensate for loss of soil nutrients and setting the balance among the nutrients to maximize the productivity. In this regard, the NPK ratios in Egypt are 1:0.19:0.05. However, it is 1:0.58:0.54 in the developed countries[3]. It can be summarized that the NPK fertilization in Egypt is characterized by the heavy use of N, high P and low K rates. In Egypt, the ratio between K/N is lower than the ratio of global use of fertilizer[4]. The Egyptian researchers made great efforts to improve wheat productivity[5–7]. Also, the response of wheat to nitrogen, phosphorus and potassium as an individual nutrient or in integration is reviewed[8] and the results obtained confirmed the important role of balanced fertilization[9]. Added to NPK as soil application, micronutrients can be used as foliar application. In this regard, balanced nutrition leads to increase the efficiency of all nutrients applied and, thus reducing the amount of fertilizers used. Therefore, this research was carried out to investigate the effect of NPK doses calculated considering soil testing alone and/or in combination with spraying micronutrients on yield and nutrient uptake of wheat plants compared with farmer's fertilization and other recommended doses.

2. Materials and Methods

Experiments were carried out in the farmer's field in Kafer El Kadera village, El–Monofia governorate, Egypt, during winter seasons from 2009 to 2013 using wheat (var., Sakha, 93).

Before wheat planting, a representative soil sample was taken before sowing every season to test physical and chemical properties. Wheat grains were sowing in 20th October each season. Six NPK combinations were tested+ control treatment

T0 = Control (NPK = 0:0:0 Kg/ha.)

T1 = N: P_2O_5: K_2O (farmer's fertilizer) 95:71:0 kg/ha.

T2 = N: P_2O_5: K_2O (MoA) 143: 119:114 kg/ ha.

T3 = N: P_2O_5: K_2O (MoA) 143: 119: 0 kg/ ha.

T4 = N: P_2O_5: K_2O (MoA) 143: 0:114 kg/ ha.

T5 = N: P_2O_5: K_2O (considering soil testing) 190:143:131 kg/ha.

T6 = N: P_2O_5: K_2O (considering soil testing) 190: 143: 131 kg/ ha. + Micronutrients

Fertilizers were applied to the soil at 30 days after sowing as ammonium nitrate 33.5%N, single superphosphate 15.5% P_2O_5, and potassium sulphate 48% K_2O). Micronutrients used as a foliar application at 45 days after sowing using cheated micronutrient compound (3% Fe: 3% Zn: 3% Mn) at rate of 1.5 g/l. water. The volume used was 600 L/ha.

Leaf samples from each plot at 75 days after sowing were analyzed for nutrients. After complete maturity, one-meter square was taken to determine yield and yield components, Wheat nutrient contents and uptake were calculated in grains.

Samples of soil were analyzed for texture with a hydrometer[10], for pH and electric conductivity (EC) using water extract method (1 soil: 2.5 water) method[11], total calcium carbonate ($CaCO_3$%) by calcimeter method[12]. Organic matter (O.M %) content using potassium dichromate[13]. Phosphorus was extracted using sodium bicarbonate[14]. Potassium, calcium, magnesium and sodium were extracted using ammonium acetate[11]. Iron, manganese, zinc and copper were extracted using DPTA[15].

The plant material was digested using acid mixture[16]. Total N was determined according to the method[17]. Phosphorus was photometrically determined using the molybdate vanadate method[11]. Potassium, calcium and Sodium were determined using Flame photometer. Mangnesium, Fe, Mn, Zn and Cu were determined using the Atomic absorption spectrophotometer, according to method[17].

The soil data were evaluated using the criteria published[18,19]. Whereas the leaf analysis data were evaluated according to the criteria mentioned in Plant Analysis Handbook[20]. Also, the average net economic benefit calculated for each treatment. Data were subjected to the analysis of variance of Randomized Complete Block Design (RCBD), where the means of different treatments were compared using the least significant difference (L.S.D) test at 5% probability level[21].

3. Results and Discussion

3.1 Soil Testing

Results in Table 1 show the physical properties of the soil where, experiments were done. The soil was clay

Table 1. Average of soil analyses before sowing (0-30cm depth)

Character	Nutrient content (mg /100g)
Sand % 31	Available – P 3.56 H
Silt % 28	Available - K 30.5 M
Clay % 41	Available - Mg 49.5 M
Soil Texture Clay	Available - Ca 109 M
pH 8.54 H	Available - Na 16.1 L
E.C dS/m 0.15 L	(mg/Kg)
$CaCO_3$ % 1.41L	Available - Fe 11.0 M
O.M % 2.06 M	Available - Mn 13.9 H
	Available - Zn 3.4 H
	Available - Cu 3.1 H

L = Low M = Moderate, H = High

in texture and alkaline in reaction. The total content of calcium carbonate and soil salinity tend to be low while the organic matter was medium. Also, according to the critical values of available nutrient concentrations mentioned[18, 19]. Data in Table 1 shows that all nutrients are between medium and high levels except Na was low.

3.2 Yield and its Components

Tables 2 and 3 showed that the number of spike/m^2, number of grains/spike, weight of grain/spike, 1000-grains weight, grains yield ton/ha, biological yield ton/ha and harvest index % were significantly affected by the treatments.

Treated wheat plants with (N190 P143 K131) considering soil testing + micronutrients foliar spray significantly increased number of spike/m^2, number of grains/spike, weight of grain/spike, 1000-grains weight, grains yield ton/ha, biological yield ton/ha and harvest index by 37, 27, 67, 18, 66, 43 and 16% respectively, followed by the treatments of (N190 P143 K131) considering soil testing. On the other hand, control was the lowest one. Wheat treated with (N143 P119 K114) and (N143 K114) treatments,

Table 2. Yield, yield components of wheat (Sakha 93) as affected by some NPK treatments (average of seasons 2009-2013)

Treatment	Spike number (m^2)	Grain number/ Spike	Weight of grain spike(g)	1000-grain weight (g)	Grain yield ton/ha	Biological yield ton/ha	Harvest index (%)
Control (T0)	274.1	45.9	1.59	36.8	4.289	11.675	36.7
Farmer Fertilizer (T1)	305.8	49.8	2.00	39.1	5.028	12.778	39.3
NPK, MoA (T2)	345.3	54.6	2.27	41.5	6.135	14.03	43.7
NP, MoA (T3)	329.1	50.2	2.03	41.0	5.757	13.54	42.5
NK, MoA (T4)	352.5	52.1	2.21	40.6	6.301	14.245	44.2
NPK soil test (T5)	376.1	58.1	2.66	43.6	7.113	16.648	42.7
NPK soil test + micronutrients (T6)	392.0	59.5	2.69	44.6	7.901	17.095	46.2
LSD. 5%	29.9	1.28	0.31	2.97	0.679	1.21	4.0

Table 3. Ratios of increase in the yield, yield components of wheat (Sakha 93) attributed to control (100) as affected by some NPK treatments (average of seasons 2009-2013)

Treatment	Spike number	Grain number/ spike	Weight of grain spike	1000-grain weight	Grain yield	Biological yield	Harvest index
Control (T0)	100	100	100	100	100	100	100
Farmer Fertilizer (T1)	116	108	126	106	117	109	107
NPK, MoA (T2)	126	119	143	113	143	120	119
NP, MoA (T3)	120	109	128	111	134	116	116
NK, MoA (T4)	129	114	139	110	147	122	120
NPK soil test (T5)	137	127	167	118	166	143	116
NPK soil test + micronutrients (T6)	143	130	169	121	184	146	126

gave results better than those obtained by the treatment of (N143 P119) according to ministry of Agriculture.

The highest grain of 7083 Kg ha^{-1} was obtained from plot fertilized at the rate of 140-75-50 Kg NPK ha^{-1} [8]. And the application of 150 kg N+100 kg P_2O_5 ha^{-1} to Inqlab-91 and 150-100 kg NP ha^{-1} to Punjab-85 wheat cultivars gave highest yield[22]. Also, yield of grain had a significant positive correlation with utilization efficiency and uptake of potassium[23].

Nitrogen, PK levels significantly affected plant height, number of tillers, 1000-grain weight, grain yield. The highest grain yield (4.99 t ha^{-1}) was obtained with the application of 105-75-75 kg NPK ha^{-1}[24].

Similar to our findings, the highest grain yield of 5168 Kg ha^{-1} was recorded with the application of 175-150-125 NPK Kg ha^{-1} [25]Also, fertilized by P, K, Ca, Mg, S, B, and Zn and increasing fertilization of N ha^{-1} to 210 kg N raised grain yield and plant height[26].

Using micronutrients as foliar application at tillering and/or booting and milking growth stages increased grain. And straw yields of wheat[27]. Foliar of zinc and iron increased grain yield and its quality compared with control[28]. Supplying these micronutrients in intensive cropping; should be considered to prevent depletion of nutrients[29]. Micronutrients application increased the yield and growth parameters of wheat[30]. Similar to that, micronutrient significantly raised plant height, number of spike /plant, number of grain/ spike, 1000-grain weight, grain yield, harvest index and biological yield of wheat[31].

Also, foliar application of micronutrients produced the highest values of plant height, tillers number, spikes number, spike length, number of spikelets spike^{-1}, number of grains spike, 1000- grain weight, grain, straw, biological yield and harvest index[32]. It is possible to obtain maximum yield and its components, chemical composition and quantitative technological of grain wheat through soil application of mixture of (nitrogen + potassium) and foliar of Zn + Fe[33]. Foliar application substantially improved plant height, spike length, spikelets/spike, grains/spike, Tillers, grain and biological as well as harvest index of wheat.

Foliar application of Fe_4 + Mn + Zn in the form of sulphate was comparatively better regarding yield of wheat[34]. Also, microelement foliar application recorded significant differences in yield and yield components[35].

Data presented showed that balanced fertilization with NPK and micronutrients can maximize wheat yield. However, the application of potassium in combination with nitrogen and phosphorus resulted in more crop harvest; Also, it can be explained that added micronutrients along with macronutrients led to increased utilization rate of macronutrients, which reflected on the yield and its components, so the use of micronutrients as foliar application is highly recommended for yield increase.

3.3 Nutrient Concentrations in Leaves

Based on sufficient values of nutrients mentioned in Table 4, data in Table 5 shows that levels of both N and P are low, and K, Ca and Mg levels were medium. Micronutrients showed an optimal range, except Fe was high content. Aso, N, P, K, Ca, Mg, Fe, Mn, Zn and Cu nutrient concentrations in flag wheat leaves treated with NPK considering soil testing + micronutrients (T6) were improved as compared with control, but were not significant in P, Ca, Mg Na and Cu. However, still some of the nutrients without the appropriate level.

In this concern, some authors found that wheat is susceptible to zinc and copper deficiency[36]. Micronutrients foliar spray significantly improved micronutrient concentrations in flag leaf and grains of wheat[37].

Table 4. Sufficient values of macro and micronutrients for Flag leaf of wheat (dry weight basis) [20].

Nutrient (%)	Values	Nutrient (ppm)	Values
N	3.50-4.50	Fe	50-250
P	0.30-0.50	Mn	35-475
K	2.00-3.00	Zn	15-70
Ca	0.20-0.50	Cu	5-25
Mg	0.20-0.60		
Na			

Table 5. Nutrient concentrations and evaluation of wheat flag leaves as affected by different levels of NPK and balanced fertilization (average of seasons 2009-2013)

Treatment	%							ppm		
	N	P	K	Ca	Mg	Na	Fe	Mn	Zn	Cu
Control (T0)	2.87 L	0.23 L	2.51 S	0.58 H	0.57 S	0.10 L	267 H	57 S	45 S	7 S
Farmer Fertilizer (T1)	3.08 L	0.25 L	2.65 S	0.54 S	0.62 S	0.10 L	270 H	56 S	49 S	7 S
NPK, MoA (T2)	3.27 L	0.23 L	2.59 S	0.57 H	0.62 S	0.10 L	261 H	58 S	50 S	10 S
NP, MoA (T3)	3.20 L	0.24 L	2.51 S	0.56 H	0.54 S	0.11 L	259 H	64 S	49 S	9 S
NK, MoA (T4)	3.20 L	0.25 L	2.71 S	0.61 H	0.56 S	0.11 L	255 H	60 S	52 S	9 S
NPK soil test (T5)	3.23 L	0.24 L	2.61 S	0.69 H	0.64 S	0.13 L	275 H	63 S	51 S	9 S
NPK soil test + micro-nutrients (T6)	3.35 L	0.26 L	2.82 S	0.60 H	0.63 S	0.12 L	292 H	68 S	56 S	11S
LSD. 5%	0.30	N.S	0.18	N.S	**N.S**	**N.S**	**22**	6	**3**	**N.S**

L = Low S = Sufficient H = High

3.4 Grain Nutrient Concentrations

Results in Table 6 showed that NPK considering on soil testing + micronutrients (T6) significantly increased K, Ca, Mg and Mn as compared with control. Also, there were no significant differences among treatments for N, Zn and Cu. This may be due to the depletion by an increase in grain yield. In contrary, foliar spray of Zn increased zinc in grain nearly to threefold comparison with control (from 18.7 to 50.9 $mg.Kg^{-1}$)[28], also, accumulation of Zn, Fe and Mn in wheat grain were found, foliar

Table 6. Nutrient concentrations in grains of wheat as affected by different levels of NPK and balanced fertilization (average of seasons 2009-2013)

Treatment	%						ppm			
	N	P	K	Ca	Mg	Na	Fe	Mn	Zn	Cu
Control (T0)	2.77	0.31	0.58	0.18	0.28	0.027	163	34	40	5.5
Farmer's Fertilizer (T1)	2.53	0.28	0.56	0.23	0.27	0.031	181	38	40	4.9
NPK, MoA (T2)	2.73	0.32	0.59	0.25	0.30	0.024	169	35	39	5.2
NP, MoA (T3)	2.69	0.32	0.59	0.25	0.31	0.031	167	35	41	5.8
NK, MoA (T4)	2.69	0.27	0.58	0.27	0.29	0.029	166	35	44	6.3
NPK soil test (T5)	2.67	0.30	0.68	0.31	0.33	0.043	173	38	44	5.6
NPK soil test + micro-nutrients (T6)	2.65	0.32	0.66	0.28	0.30	0.027	155	42	41	5.7
LSD. 5%	N.S	0.02	0.03	0.04	0.02	N.S	10	2	N.S	N.S

application of Zn, Fe and Mn fertilization should be recommended in wheat[38].

3.5 Grain Nutrient Uptake

Data presented in Table 7 indicated that the uptake of all nutrients was significantly increased with the application of NPK considering soil testing + micronutrients (6) as compared with control.

The above mentioned results are in a harmony with that spraying wheat plants with micronutrients either in non-chelated or chelated form can improve the physiological performance of sprayed plants and increase macronutrients uptake of plants from soil as well as increase plants dry matter accumulation[5]. Also, application of recommended NPK improved micronutrient (Fe) uptake appreciably[30].

Table 7. Nutrient uptake in grains of wheat (average of seasons 2009-2013)

Treatment	Kg/ha						g/ha			
	N	P	K	Ca	Mg	Na	Fe	Mn	Zn	Cu
Control (T0)	122.2	13.5	24.2	7.4	11.5	1.16	673	148	168	22.3
Farmer's Fertilizer (T1)	130.3	14.4	27.9	11.5	13.5	1.50	901	192	203	24.8
NPK, MoA (T2)	169.1	19.5	36.0	15.1	18.3	1.50	1030	215	242	32.5
NP, MoA (T3)	158.6	18.7	33.1	14.3	17.6	1.56	954	200	238	32.0
NK, MoA (T4)	173.4	17.5	36.7	16.3	18.1	1.76	1037	220	276	39.5
NPK soil test (T5)	184.2	20.5	48.8	23.2	24.2	2.00	1258	271	318	41.8
NPK soil test + Mi (T6)	206.8	24.8	52.6	22.5	24.2	2.01	1237	331	322	46.3
LSD. 5%	17.1	1.8	3.0	2.9	1.8	0.28	154	39	17	4.3

3.6 Economic Benefit

Data presented in Table 8 showed extra fertilizers input cost against extra crop (grain and straw) cost and return on investment for each treatment. Return on investment revealed that balanced fertilization was economically viable in NPK considering soil testing + micronutrients (T6). Our findings are in line with that the maximum net profit was gathered in foliar spray of micronutrients at tillering + booting + milking growth stages of wheat[27] and that maximum net economic returns were recorded when applied commercial micronutrients mixture (Fe = 1%, Mn = 2%, Zn = 2%, Cu = 1%, B = 1%) at tillering,

Table 8. Yield increases / extra cost and benefit from the different treatments

Treatment	Grain yield (ton/ ha)	Straw yield (ton/ ha)	Extra grain (ton/ ha)	Extra straw (ton/ ha)	Price of Extra Yield/ha			Extra cost of fertilizers/ha					(1)-(2) (ROI)
					Grain	Straw	Total (1)	N	P	K	Mi	Total (2)	
T0	4.289	7.386	-	-				-	-	-	-	-	
T1	5.028	7.750	0.739	0.364	1726	164	1890	624	687	-	-	1311	579
T2	6.135	7.895	1.846	0.509	4310	229	4539	939	1152	1596	-	3687	852
T3	5.757	7.783	1.468	0.397	3428	179	3607	939	1152	-	-	2091	1516
T4	6.301	7.944	2.012	0.558	4698	251	4949	939	-	1596	-	2535	2414
T5	7.113	9.535	2.824	2.149	6594	967	7561	1248	1384	1834	-	4466	3095
T6	7.901	9.194	3.612	1.808	8434	814	9248	1248	1384	1834	50	4516	4732

ROI=Return on investment

jointing, booting and earing[39]. Also, with that farmers got addition return with incremental benefit cost ratio of 4.7 by application of an integrated and balanced fertilization program in wheat[40], and by using foliar application of micro elements with drilling on terraces sowing method, farmers gain the highest profit[35].

4. Conclusion

Under the conditions of this study, on the basis of these results it is concluded that 190, 143, 131 kg ha^{-1} N, P_2O_5 and K_2O was the suitable fertilizer doses combined with micronutrients as foliar application to obtain maximum and economic yield of wheat.

5. Acknowledgment

We wish to acknowledge with appreciation the support of the International Plant Nutrition Institute and special thanks are also due to Prof Dr. Munir. Rusan the IPNI Middle East Consulting Director – Jordan University of Science and Technology for the vital help and support.

Authors are obliged to Prof Dr. Mohamed Soliman Zeidan, Field Crop Research Dept., NRC, Cairo, for his sincere help during the field visits in the first and second seasons. This work was achieved with the facilities of the Project "Micronutrient and Plant Nutrition Problems in Egypt".

6. References

1. Food and Agriculture Organization. Statistical Yearbook. Food and Agriculture Organization of the United Nations, Rome; 2016.
2. Dixon J, Braun, HJ, Crouch JH. Overview: Transitioning wheat research to serve the future needs of the developing world. Provisional Wheat Facts and Futures Overview; 2008. p. 44. PMid:19186601.
3. Taha MH. Use of chemical fertilizers in Egypt. National Workshop on Chemical Fertilization. Oman Arab Organization for Agriculature. Development, League of Arab States (in Arabic); 1996. p. 342–8
4. El-Fouly MM, Fawzi AFA, Firgany AH. Removal of nutrients by Trifolium alexandrinum and effect of NPK fertilization on yield. Mediterranean Potash News. 1987; 3:8–10.
5. Abdalla FE, Mobarak ZM, El-Sayed. AA. Effect of micronutrients foliar application on uptake of macronutrients by wheat and faba bean. African Journal for Agricultural Sciences. 1992; 19(1):181–92.
6. Sary GA, El-Naggar HM, Kabesh MO, El-Kramany MF, Bakhoum G Sh H. Effect of bio-organic fertilization and some weed control treatments on yield and yield components of wheat. World Journal of Agricultural Sciences. 2009; 5(1):55–62.
7. Shaaban SHA, Manal FM, Afifi MHM. Humic acid foliar application to minimize soil applied fertilization of surface-irrigated wheat. World Journal of Agricultural Sciences. 2009; 5(2):207–10.
8. Maqsood M, Akbar M, Yousaf N, Mehmood TM, Ahmad S. Effect of different rate of N, P and K combinations on yield and components of yield of wheat. International Journal of Agricultural and Biological. 1999; 1(4):359–61.
9. Abbas G, Khattak JZK, Mir A, Ishaque M, Hussain M, Wahedi HM, Ahmed MS, Ullah A. Effect of organic manures with recommended dose of NPK on the performance of wheat (Triticum aestivum L.). The Journal of Animal & Plant Sciences. 2012; 22(3):683–7.
10. Bouyoucos HH. A recalibration of the hydrometer for making mechanical analysis of soils. Agronomy Journal. 1954; 43:343–8.
11. Jackson KL. Soil chemical analysis. Prentice Hall of India Private limited, New Delhi, India; 1973.
12. Alison LE, Moodle CD. Carborate. In: C.A. Black (edition) Methods of Soil Analysis. American Society of Agronomy. Madison, Wisconsin, USA; 1965. p. 1379–96.
13. Walkley A, Black IA. An examination of the Degtjareff method for determining organic matter and a proposed modification of the chromic acid titration method. Soil Science. 1934; 37(1):29–38. Crossref.
14. Olsen SR, Cole CW, Watnable SS, Dean LA. Estimation of available phosphorus in soil by extraction with sodium bicarbonate. Agriculture Circular USDA. 1954; 930:1–19.
15. Lindsay WL, Norvell WA. Development of a DTPA micronutrient soil tests for zinc, manganese and copper. Soil Science Society of America Journal. 1978; 42:421. Crossref.
16. Chapman HD, Pratt PF. Methods of analysis for soils, plants and waters. Division of Agricultural Science University. California, Berkeley. USA; 1978. p. 309.
17. Cottenie AM, Verloo L, Kiekens GV, Camerlynck R. Chemical analysis of plant and soil. Laboratory of Analytical and Agrochemistry, State University. Ghent, Belgium; 1982. p. 100–29.

18. Ankerman D, Large R. Soil and plant analysis. Tech Bulletin Agricultural & laboratories Inc. New York, USA; 1974. p. 42–4, 74–6.

19. Silvertooth JC. Soil fertility and soil testing guidelines for Arizona cotton. Cooperative Extension. The University of Arizona. USA; 2001. p. 1–2.

20. Jones BJ, Wolf B, Mills HA. Plant Analysis Handbook: a practical sampling, preparation, analysis, and interpretation guide. Publishing Micro- Macro. Athens, Georgia USA; 1991. p. 187.

21. Snedecor GW, Cochran WG. Statistical methods. 8th Edition Iowa State University press. The Journal of Agricultural Science. 1990; 115(1):1–153.

22. Abbas G, Irshad A, Ali M. Response of three wheat (Triticum aestivum L.) cultivars to varying applications of N and P. International Journal of Agriculture and Biology. 2000; 2(3):237–8.

23. Mahmood T, Gill MA, Waheed T, Ahmad Z, Rehman H. Potassium deficiency-stress tolerance in wheat genotypes II: Soil culture study. International Journal of Agriculture and Biology. 2001; 3(1):117–20.

24. Hussain MI, Shamshad HS, Sajjad H, Khalid I. Growth, yield and quality response of three wheat (Triticum aestivum L) varieties to different levels of N, P and K. International Journal of Agriculture and Biology. 2002; 4(3):362–4.

25. Malghani A, Malik A, Sattar A, Hussain F, Abbas G, Hussain J. Response of growth and yield of wheat to NPK fertilizer. Science International (Lahore). 2010; 24(2):185–9.

26. Hirzel J, Matus I. Effect of soil depth and increasing fertilization rate on yield and its components of two durum wheat varieties. Chilean Journal of Agricultural Research. 2013; 73(1):55–9. Crossref.

27. Hussain N, Khan MA, Javed MA. Effect of foliar application of plant micronutrient mixture on growth and yield of wheat (Triticum aestivum L). Pakistan Journal of Biological Sciences. 2005; 8(8):1096–9. Crossref.

28. Habib M. Effect of foliar application of Zn and Fe on wheat yield and quality. African Journal of Biotechnology. 2009; 8(24):6795–8.

29. Yassen A, Abou El-Nour EAA, Shedeed S. Response of wheat to foliar spray with urea and micronutrients. Journal of American Science. 2010; 6(9):14–22.

30. Abbas G, Hussain F, Anwar Z, Khattak JZK, Ishaque M, ullah A. Effects of iron on the wheat crop (Triticum aestivum L) by uptake of nitrogen, phosphorus and potassium. Asian Journal of Agricultural Sciences. 2012; 4(3):229–35.

31. Bameri M, Abdolshahi R, Mohammadi-Nejad G, Yousefi K, Tabatabaie SM. Effect of different microelement treatment on wheat (Triticum aestivum) growth and yield. International Research Journal of Applied and Basic Sciences. 2012; 3(1):219–23.

32. Mekkei MER, El Haggan Eman AMA. Effect of Cu, Fe, Mn, Zn foliar application on productivity and quality of some wheat cultivars (Triticum aestivum L). Journal of Agriculture- Food and Applied Sciences. 2014; 2(9):283–91.

33. Gomaa MA, Radwan FI, Kandil EE, El-Zweek SMA. Effect of some macro and micronutrients application methods on productivity and quality of Wheat (Triticum aestivum L). Middle East Journal of Agriculture Research. 2015; 4(1):1–11.

34. Zain M, Khan I, Qadri R, Ashraf U, Hussain S, Minhas S, Siddique A, Jahangir M, Bashir M. Foliar application of micronutrients enhances wheat growth, yield and related attributes. American Journal of Plant Sciences. 2015; 6:864–9. Crossref. https://doi.org/10.4236/ajps.2015.67094

35. Said MT, Ameen FA. Effect of sowing methods and microelements foliar application on bread wheat productivity and their economical feasibility. Egyptian Journal of Agronomy. 2016; 38(2):225–40. Crossref.

36. Abdel-Maguid AA, El-Fouly MM. Copper as a yield limiting nutrient for wheat. Bulletin of Faculty of Agriculture Cairo University. 2004; 55:385–400.

37. Rawashdeh H, Sala F. Effect of some micronutrients on growth and yield of wheat and its leaves and grain content of iron and boron. Bulletin UASVM Agriculture. 2015; 72(2):503–8. Crossref.

38. Narwal RP, Malik RS, Dahiya RR. Addressing variations in status of a few nutritionally important micronutrients in

wheat crop. World Congress of Soil Science, Soil Solutions for a Changing World. Brisbane, Australia; 2010. p. 1–3.

39. Khan MB, Farooq M, Hussain M, Shanawaz and Shabir G. Foliar application of micronutrients improves the wheat yield and net economic return. International Journal of Agriculture and Biology. 2010; 12(6):953–6.

40. Rezk AI, El-Nasharty AB, Nofal OA. Technology using integrated and balanced nutrients management for higher production in wheat. Journal of Applied Sciences Research. 2012; 8(5):2753–7.