Soil Sciences

Nutritional Status of Some Calcareous Soil of Saudi Arabia as Influenced by Intensive Fertilization of Wheat Grown under Pivot Irrigation System

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(Received 27/12/1420; accepted for publication 18/12/1421)

Abstract. Wheat growers in the Kingdom of Saudi Arabia usually overdose the amount of fertilizers applied. Such intensive applications of fertilizers led us to appraise the nutritional status of soil. To achieve this goal eleven farms growing wheat under central pivot system were selected. These farms represented a comparatively short period of cultivation (less than ten years) and long one (more than 10 years). Soil samples representing three depths namely: 0-15, 15-30, 30-45 cm were taken from inside the central pivots and from its outer uncultivated zone. The long period of cultivation elevated the available N and P throughout the soil depths. Only a significant increase was recorded for the N of the first soil layer and P in the upper two consecutive layers. In comparison, the short cultivation period significantly accentuated the available N and P in the first soil layer. Available Mn, Zn, and Cu were significantly increased due to intensive fertilization of wheat cultivated for either short or long period. However, Fe showed nonsignificant increase. Comparing total nutrient contents of the cultivated and non cultivated soils, the results indicated that total P increased significantly in the first layer while a decline trend occurred in the case of K; probably due to lack of K application. Conclusions as to the more important measures to be taken towards achieving more efficiency in fertilizer use are drawn

Introduction

Most farmers in the Kingdom of Saudi Arabia tend to apply more fertilizer than would be needed by the crop in most seasons. This could result in a general build up in the various nutrient status of many agricultural soils. While this accumulation may be generally desirable to boost production, yet it might not be cost effective because excessive application of fertilizers often leads to large losses of nutrients from the agricultural system and may cause nutrients imbalance in soil. With only about half of the applied fertilizers getting into the crop [1], there is a potential for marked economic losses and for negative environmental impacts.

The unbalanced use of fertilizers has created a number of environmental problems. Chief among these problems are the contributions of phosphate and nitrogen compounds to the eutrophication of surface waters, and the excessive concentration of nitrogen compounds in water and the atmosphere [2]. Furthermore the increased concentration of many plant nutrients in both surface and ground water could create a potential health hazard [3-4]. Also high level of P and K in soils may give rise to micronutrient imbalances ; Zn deficiency in soils with high P levels, [5]or Mg deficiency in soils of high K level. Fertilizer application may also result in increased growth of weeds and higher incident of pests and diseases. Collectively, these and other associated problems raise the question of how to keep the sustainability of a system that is highly dependent upon intense fertilizer inputs. The magnitude of accumulation of nutrients in the soil, however, has been found to vary with the soil type, nature and intensity of cropping and the amount of fertilizer added [6-8].

Sustainable nutrient management requires regular and continuous monitoring of the nutrient status of the soil. Hence, the continuous appraisal of soils under the prevailing conditions would provide tools for better nutrient management, optimum economic return from applied fertilizers, and checking their potential environmental hazards. Such appraisal should be based on data collected after relatively long-term farming. Such data could provide information on the accumulation and transformation of added fertilizers nutrient in soil and their fate, besides providing the basis for possible modifications of the current practices to optimize fertilizer applications. The accumulation of the various nutrients in soils as a result of long-term application of fertilizers has been well documented in many different countries [9-10]. However, in the Kingdom, data of this nature is not available. Thus, the objective of this study was to assess the soil fertility status, as affected by intensive use of inorganic fertilizers in Saudi Arabia. To achieve this goal, knowledge of the various nutrient levels in the soil is thought to be important. This knowledge is needed for better utilization of nutrients, preventing avoidable losses, and minimizing expensive inputs.

Materials and Methods

In order to evaluate the effect of intensive application of inorganic fertilizers on soil fertility, eleven farms were chosen. These farms belong to three main agricultural communities in Al-Kharj area (24°11′ N latitude and 74° 10′ E longitude) namely; Al-Kharj, Al-Dobiha and Harad. These areas are situated in the eastern side of the Najd plateau, having often a flat topography. As this district lies in the arid region, being of low precipitation (85-100 mm annually), the underground water is the only reliable source for irrigation. Selection was done in such a way that the chosen farms represented two periods of cultivation; short, less than 10 years (T1) and long, more than 10 years namely from 10 to 15 years (T2). Five farms (F1-F5) and six farms (F6-F11) represented the short and long periods of cultivation, respectively. All of these farms have received higher rates of inorganic fertilizers, particularly N and P, and rely on central pivots for irrigation. A mount of fertilizers added was obtained from information provided by the farmers. Farmers' estimates of fertilizers added were double-checked to ensure its reliability. Amounts of added fertilizers are presented in Table 1. Soil samples were collected from seven locations inside the pivot and 3 locations from its outer sphere. Samples representing the outer sphere were taken from sites far enough from the cultivated area to make sure that they do not receive any ferilizers by drizzles or mist. The main characteristics of the soils are given in Table 2.

Table1.Rates of fertilizers applied to different farms

Farm	Fertilizers			Micronutrients
	N	P	K	
F1	500 kg Urea/ha	400kg DAP/ha	0	10kg fertal/ha+2.5 L Wuxal
F2	400 kg urea/ha	434kg TSP/ha	0	3Fe, 4Mn, 0.75Cu. 1Zn kg/ha
F3	500 kg Urea/ha	400kg DAP/ha	0	10kg fertal/ha+2.5 L Wuxal
F4	500 kg Urea/ha	520kg DAP/ha	0	2Fe, 1Mn. 0.75Cu. 1Zn kg/ha
F5	500 kg Urea/ha	500kg DAP/ha	0	2 to 3 kg (Fe.Zn, Mn&Cu)
F6	100 kg urea/ha+800 kg compound fertilizers +trace metals			
F7	450 kg Urea/ha	400kg DAP/ha	0	2 to 3 kg (Fe.Zn, Mn&Cu)
F8	460 kg Urea/ha	400kg DAP/ha	0	1 to 2 kg (Fe.Zn. Mn&Cu)
F9	450 kg Urea/ha	400kg DAP/ha	0	2 to 3 kg (Fe,Zn, Mn&Cu)
F10	450 kg Urea/ha	400kg DAP/ha	0	2 to 3 kg (Fe,Zn, Mn&Cu)
F11	500 kg Urea/ha	400kg DAP/ha	0	2 to 3 kg (Fe.Zn, Mn&Cu)

The soil samples taken from the pivot represented the cultivated soil while those taken from its outer sphere represented the virgin soil (control). Soil samples were taken from 3 depths namely: 0-15, 15-30, 30-45 cm. The samples were air dried, ground and passed through a 2-mm stainless steel sieve and used for determination of available macro and micronutrients. Total nutrient content was measured in a composite samples representing only two depths (0-15, 15-30). Water samples were also taken from each farm to test their quality at the beginning of this study. The EC of the water samples ranged between 1.7 to 3.4 dsm^{-1}, pH between 7.4-7.8 and NO_3 averaged 35mgL^{-1}. These data are commonly encountered in this area. Total phosphorus was determined by the method described by Olsen et al., [11] and detected colorimetrically using the scorbic acid method. Available N (mainly soluble NH_4-N and NO_3-N and exchangeable NH_4 were extracted by 2N KCl (Jackson 1958) [12]. DTPA extractable Fe, Zn, Cu and Mn were determined, according to Lindsay and Norvell [13], using a Perkin Elmer atomic absorption spectrophotometer 2380. The data obtained were subjected to statistical analysis using Statistical Analysis System-Analysis of Variance (SAS -ANOVA [14])

Table 2. The main characteristics of soils in the studied area

Farm	Depth	Fert.	pH	Ec dsm-1	O.M.%	CaCO3%	Sand%	Silt%	clay%
F1	D1	C	8.31	0.32	0.27	28.0	87.1	4.8	8.08
		F	7.67	0.68	0.48	19.8	89.1	3.8	7.08
	D2	C	8.75	0.25	0.21	24.5	82.1	5.8	12.08
		F	8.23	1.10	0.34	21.4	89.1	4.8	6.08
F2	D1	C	8.23	0.47	0.20	8.5	89.1	2.8	8.08
		F	8.39	0.26	0.47	9.4	86.1	2.8	11.8
	D2	C	8.33	0.50	0.13	10.1	89.1	4.8	6.08
		F	8.43	0.26	0.27	4.4	88.1	1.4	10.48
F3	D1	C	7.52	0.32	0.21	28.7	87.1	4.8	8.08
		F	7.85	1.83	0.55	26.3	79.1	10.8	10.08
	D2	C	8.29	0.32	0.18	26.5	89.1	4.8	6.08
		F	8.07	1.52	0.41	22.1	83.0	9.8	7.08
F4	D1	C	8.19	0.42	0.48	24.7	82.2	8.8	8.88
		F	7.86	1.41	0.96	25.1	76.3	10.8	12.88
	D2	C	8.13	1.77	0.48	24.9	76.3	12.8	10.88
		F	7.95	1.72	0.68	19.7	80.3	10.4	9.28
F5	D1	C	6.85	3.55	0.12	6.8	73.1	6.4	20.48
		F	7.92	1.87	0.80	8.5	81.1	5.8	13.8
	D2	C	7.81	3.18	0.34	8.4	68.1	9.4	22.48
		F	8.02	2.29	0.25	5.7	79.1	6.4	14.48
F6	D1	C	7.45	0.32	0.21	23.2	92.3	2.8	4.88
		F	8.29	0.32	0.17	26.5	89.1	4.8	6.08
	D2	C	7.81	0.52	0.34	22.4	91.1	2.8	6.08
		F	8.22	0.78	0.55	22.2	91.1	2.8	6.08
F7	D1	C	7.69	9.28	0.68	23.9	59.1	24.4	16.48
		F	7.82	5.22	0.76	28.2	49.1	40.4	10.48
	D2	C	7.62	7.09	0.43	18.3	61.1	32.4	6.48
		F	8.10	4.22	0.62	22.5	57.1	34.4	8.48
F8	D1	C	7.02	6.41	0.34	19.7	78.0	12.4	9.28
		F	8.25	0.47	0.48	18.8	74.3	12.8	12.88
	D2	C	7.79	4.06	0.14	19.9	76.3	10.8	12.88
		F	8.13	0.37	0.89	17.8	78.3	8.8	12.88
F9	D1	C	7.59	1.77	0.37	22.8	79.1	8.4	12.48
		F	7.96	2.09	0.74	24.0	82.1	0.4	12.48
	D2	C	8.12	1.67	0.25	26.9	85.1	4.0	10.88
		F	8.33	1.25	0.19	24.9	81.1	5.4	13.48
F10	D1	C	8.72	0.21	0.19	17.9	94.1	2.4	3.48
		F	7.12	0.48	0.43	18.4	93.1	2.4	4.48
	D2	C	8.92	0.32	0.13	14.8	95.1	2.2	2.68
		F	8.20	0.32	0.12	20.2	94.1	2.4	3.48
F11	D1	C	8.07	1.72	0.32	14.5	84.3	5.8	9.88
		F	6.70	0.68	0.96	15.8	76.3	10.8	12.88
	D2	C	7.87	1.88	0.14	13.9	86.3	2.8	10.88
		F	8.28	0.68	0.82	16.5	82.3	8.8	8.88

D1 (0-15cm), D2 (15-30cm)
C Control. F Fertilized

Results and Discussion

Soil nitrogen

Data presented in Table 5 show that the available N content in the cultivated soil was higher than the corresponding N content obtained in the uncultivated soil. The magnitude of increase declined with depth and became insignificant in the second and third layers for both periods of cultivation (T1, T2). An increase in soil available N with continuous application of N fertilizer has also been noticed earlier by Muthuswamy *et al.*, and Singh *et al.*, [15 -16].

Although the conclusions drawn from the data demonstrated that continuos application of N fertilizers in these soils resulted in a surplus in the nutrient balance sheet as a consequence of intensive fertilization, yet it should be noted that the surplus registered is very minute in the second and the third layers. Thus heavy N fertilizer applications are recommended to obtain high yields for most crops. In contrast, measurements under different conditions and in other parts of the world, showed that excessive N supply resulted in tremendous increases in the N concentrations throughout the soil profile [17-18].

Nitrogen is subjected to losses mainly through ammonia volatilization, denitrification, besides leaching and in contrast to most other plant nutrients, no mechanism for long term storage of fertilizer nitrogen exists in soils. Under the environmental conditions prevailing in this region, where the water table is very deep, and the precipitation is likely not enough to wash out the soil N down to the ground water table, it is expected that losses of N from soil by leaching are almost invariably too small to constitute a major avenue for nitrogen losses. However, nitrate leaching is considered to be one of the main leaks of the N cycle in various parts of the world [19]. Recently, the impact of increasing level of nitrate content in the ground water on the environment is becoming a matter of growing concern. It is worth mentioning that in this light textured soils, it is very likely that some of the added N would be leached down the profile, but not far from the root zone, because capillary migration towards the surface is likely during the resting period when the surface soil dries off. However, gaseous losses could account for the largest part of the overall nitrogen losses.

Previous work by Modaihsh, *et al.* [20-21] in Saudi Arabia revealed that a substantial proportion of N added to soil as fertilizer may be lost by volatilization. Also Mashhady [22] provided evidence of considerable N losses as volatiliztion due to high temperature and $CaCO_3$ contents. Soils in the studied area are predominantly high in its carbonate (Table 2), therefore it is expected that the N losses as volatiliztion is very high as compared to other soils. Such observations indicate that the gaseous losses of N may be the major leak in the N cycle in soils of Saudi Arabia It is expected that the practice of overdosing of N in this region may lead to substantial losses of N as ammonia, rather than nitrate leaching. Undoubtedly, these gaseous losses are also wasteful and should be minimized. Attention should be paid towards more precise determination of the N doses to be applied under the specific soil and environmental conditions prevailing in Saudi Arabia. In addition, efforts should be directed towards increasing the efficiency of fertilizer N through the use of controlled release synthetic nitrogen fertilizers, nitrification inhibitors, and the well-known traditional approaches such as split dressing of N and foliar N application.

Soil phosphorus

Results presented in Table 3 indicated that the initial level of the total P in the surface soil (0-15cm) markedly increased as a result of continuous cropping and P fertilization. The total P increased from 274mgkg^{-1} to 345 mgkg^{-1}. In the second layer P increased from 197 to 263mgkg^{-1}. Data in Table 4 demonstrated that cultivation in the short period raised the total P content significantly in the first layer from 273 to 358 mgkg^{-1}, whereas there was no increase in the second layer. As for the long period of cultivation, the results demonstrated that the increase in total P was significant in the first and second layers.

Table 3. Effect of fertilization and cultivation period on total content of macronutrients in the soil of different farms

Farm	Depth	Fert.	N	P	K
				mg kg^{-1}	
F1	D1	C	406	240.5	1080
		F	336	314	780
	D2	C	350	222	1220
		F	406	240.5	800
F2	D1	C	448	216	1050
		F	448	306	580
	D2	C	434	153.5	720
		F	434	144.5	620
F3	D1	C	434	193.5	950
		F	434	415	1020
	D2	C	378	222	880
		F	462	267.5	1000
F4	D1	C	336	290	565
		F	364	434	510
	D2	C	406	254.5	520
		F	396	297.5	510
F5	D1	C	434	427.5	1130
		F	462	322.8	800
	D2	C	406	168	830
		F	504	222	400
F6	D1	C	420	173	580
		F	434	380.5	550
	D2	C	322	135.5	580
		F	364	240.5	720
F7	D1	C	490	370	3000
		F	812	206.5	2320
	D2	C	546	314	2700
		F	560	370	3000
F8	D1	C	460	260.5	580
		F	364	427.5	750

Table 3. (Contd.)

Farm	Depth	Fert.	N	P	K
				mg kg-1	
	D2	C	378	142.5	435
		F	406	350	720
F9	D1	C	350	314	1130
		F	560	427.5	1260
	D2	C	420	254	1190
		F	490	306	1600
F10	D1	C	434	144.5	660
		F	420	254	680
	D2	C	434	127	600
		F	448	168	830
F11	D1	C	420	267.5	600
		F	560	240.5	640
	D2	C	364	173	410
		F	420	360	680

D1 (0-15cm), D2 (15-30cm)
C Control, F Fertilized

Table 4. Effect of cultivation period and fertilization on total macronutrients contents in the soil

Time	Depth	Fert.	N	P	K
				mg kg-1	
T1	D1	C	411.6	273.5	955.0
		F	408.8	358.3	738.0
	D2	C	394.8	204.0	834.0
		F	440.4	234.4	666.0
T2	D1	C	429.0	254.9	1091.7
		F	525.0	332.8	1033.3
	D2	C	410.7	191.0	985.8
		F	448.0	299.1	1258.3
LSD(0.05)			97.8	83.2	818.8

T1 Cultivated for less than 10 Years
T2 Cultivated for more than 10 Years
D1 (0-15cm), D2 (15-30cm), D3 (30-45cm)
C Control, F Fertilized

On the other hand, the available P content registered a significant increase in the first layer whereas in the 2nd and 3rd layers there was no increase (Table 5). The increase was more pronounced in the long-term cultivation period (T2), where a significant increase occurred in The first and second soil layer (7.5-18.1; 4.5-7.8 $mgkg^{-1}$). The build up of available P as a result of cultivation can be ascribed to the increase in the available P pool of soil phosphorus after satisfying the P fixation capacity as result of continuous cropping and fertilization. Several workers [23-24] indicated that addition of fertilizer P in excess of the crop requirements, could enrich the soil P reserves and increase the availability of soil phosphorus. The increase in soil test P to varying extent, with regular dressings of phosphatic fertilizer for eight years to a fine sandy loam soil, was also reported by McCollum [7].

Table 5. Effect of fertilization and cultivation priod on available nutrients in the soil of different farms

Farm	Depth	Fert.	N	P	K	Fe	Zn	Mn	Cu
			mg kg-1						
F1	D1	F	40.87	16.17	109.00	4.22	0.55	5.45	0.49
		C	31.48	6.05	137.50	3.26	0.29	2.02	0.60
	D2	F	33.60	8.17	74.70	2.93	0.30	2.25	0.30
		C	30.80	4.53	91.50	2.93	0.25	1.24	0.64
	D3	F	31.73	5.72	72.00	2.54	0.21	1.27	0.27
		C	22.12	2.53	65.50	2.52	0.17	0.86	0.48
F2	D1	F	18.60	8.08	53.70	2.81	0.59	4.70	0.33
		C	20.40	0.78	142.50	2.49	0.30	1.87	0.39
	D2	F	30.80	2.38	38.30	2.41	0.45	1.91	0.27
		C	15.90	1.35	146.00	2.78	0.19	1.09	0.33
	D3	F	20.35	1.67	31.70	2.33	0.33	1.33	0.24
		C	20.16	0.62	72.00	2.53	0.15	0.90	0.28
F3	D1	F	60.49	14.17	90.70	2.44	0.63	4.78	0.82
		C	28.93	4.87	68.00	2.69	0.22	1.22	0.42
	D2	F	36.83	4.85	84.30	1.97	0.33	2.14	0.55
		C	30.82	4.43	90.00	2.46	0.36	1.48	0.44
	D3	F	34.15	2.45	84.00	1.65	0.32	0.73	0.55
		C	30.39	3.47	76.00	2.92	0.27	1.35	0.39
F4	D1	F	70.20	15.07	66.00	1.80	0.81	6.81	0.39
		C	30.24	7.00	103.50	2.70	0.20	1.77	0.40
	D2	F	30.01	4.81	53.30	1.82	0.52	2.39	0.34
		C	36.62	3.80	92.50	2.34	0.34	1.93	0.41
	D3	F	30.10	4.48	51.60	1.80	0.19	0.97	0.36
		C	37.52	4.10	86.50	2.19	0.24	1.90	0.20
F5	D1	F	45.17	13.15	68.70	2.10	0.71	2.47	0.87
		C	31.92	4.75	200.00	1.80	0.41	1.80	0.39
	D2	F	36.03	6.00	29.50	1.47	0.63	1.33	0.36
		C	34.07	3.95	166.50	1.13	0.29	1.11	0.27
	D3	F	36.02	2.90	26.70	0.82	0.41	0.79	0.27
		C	38.80	2.35	135.50	0.70	0.26	0.71	0.27
F6	D1	F	31.92	29.98	56.30	3.44	0.82	2.47	0.51
		C	31.36	7.60	60.70	2.29	0.36	1.15	0.19
	D2	F	29.50	10.71	54.00	2.43	0.38	0.75	0.35
		C	31.52	3.30	65.30	1.88	0.27	0.59	0.20
	D3	F	23.30	4.62	51.00	2.24	0.29	0.32	0.25
		C	24.92	2.63	60.00	2.05	0.26	0.50	0.15
F7	D1	F	77.47	21.40	213.30	1.35	0.48	0.58	0.63
		C	54.92	12.07	188.00	0.90	0.15	2.29	0.29
	D2	F	28.19	7.13	149.00	0.85	0.14	0.41	0.41
		C	34.51	4.02	136.00	0.79	0.10	1.32	0.23
	D3	F	22.69	1.80	158.00	0.78	0.08	0.36	0.23
		C	36.96	4.00	146.00	1.22	0.14	1.26	0.25
F8	D1	F	54.15	7.90	67.00	2.57	0.53	7.39	0.44

Table 5. (Contd.)

Farm	Depth	Fert.	N	P	K	Fe	Zn	Mn	Cu
			mg kg-1						
		C	35.98	5.12	78.00	2.34	0.20	2.73	0.36
	D2	F	29.68	2.92	56.30	2.22	0.15	1.05	0.36
		C	33.04	1.68	74.50	2.06	0.12	0.97	0.16
	D3	F	26.51	2.30	49.70	2.47	0.15	0.73	0.27
		C	23.52	2.47	75.30	1.69	0.11	0.77	0.11
F9	D1	F	74.48	15.84	78.70	1.85	0.67	2.45	0.81
		C	56.28	7.78	70.70	1.69	0.62	4.02	0.71
	D2	F	34.80	6.82	70.30	1.85	0.51	0.77	0.66
		C	33.32	6.23	56.30	1.58	0.28	1.64	0.51
	D3	F	30.98	3.90	31.30	1.59	0.26	0.47	0.50
		C	27.44	2.05	46.00	1.46	0.28	0.52	0.39
F10	D1	F	29.30	17.50	58.30	3.11	0.66	3.25	0.66
		C	17.36	5.05	48.00	3.14	0.34	1.19	0.26
	D2	F	24.45	7.50	57.70	2.85	0.44	1.33	0.53
		C	19.80	4.40	54.50	2.72	0.22	0.64	0.17
	D3	F	17.22	5.04	55.20	2.55	0.22	0.94	0.21
		C	19.04	2.20	68.00	2.90	0.20	0.64	0.16
F11	D1	F	61.61	15.88	96.70	2.00	0.85	3.28	0.53
		C	41.40	7.35	61.00	2.04	0.19	3.09	0.37
	D2	F	59.36	11.50	80.30	1.79	0.48	2.05	0.47
		C	39.01	7.48	63.00	2.53	0.15	1.96	0.27
	D3	F	48.90	3.60	53.70	1.72	0.46	0.44	0.40
		C	50.03	4.50	57.50	2.21	0.15	1.95	0.25

D1 (0-15cm), D2 (15-30cm), D3 (30-45cm)
C Control, F Fertilized

The time course of P accumulation (as $NaHCO_3$-extractable P) in cultivated soil shows that the accumulation was greater in the long period of cultivation (from 7.5 to 18.1 $mgkg^{-1}$). In the short period of cultivation (T1), the results showed a lower soil P status(4.7-13.3 $mgkg^{-1}$). These findings suggest that application of phosphatic fertilizer result in the accumulation of P in the soil, the magnitude of which depends on the period of cultivation. In this study, the continuous application of P fertilizers resulted in accumulation of $NaHCO_3$-extractable P in the surface soil to a level that is sufficient even for the succeeding crops. Earlier, Ayed and Sayed [25] indicated that the adequate level for Na bicarbonate-extractable P probably falls between 9 and 21 $mgkg^{-1}$ and crops did not respond to P when the soil test value exceeded 20 $mgkg^{-1}$. Recently, Amrani *et al.*, [26], evaluated the effect of residual P in a Moroccan calcareous soils. They showed that soils with more than 14 $mgkg^{-1}$ $NaHCO_3$ could provide adequate P for for the maximum yield of three succeeding crops. Therefore, to achieve higher fertilizer use efficiency, the soil P status should be regularly monitored to readjust the fertilizer dose.

Potassium

Data in Table 3 show a wide variation in the total K content in the soil. Concentration of total K in the studied soils varied between 400-3000 $mgkg^{-1}$. Similar result was reported earlier by Gabreel [27]. He found that the total K content in some soils of the Saudi Arabia ranged between 580-4800 $mgkg^{-1}$. Current data showed that cultivation reduced the total K content from 955 to 738 $mgkg^{-1}$ in the first soil layer and from 834 to 666 $mgkg^{-1}$ in the second soil layer. This may be attributed to lack of regular K fertilization on one hand and the lower K content in the irrigation water on the other hand.

Results presented in Table 5 indicate a decline in available K content in the cultivated soil as compared to the uncultivated soil, in the short period of cultivatin. The averages of K content were 77.6, 56.1 and 53.2 $mgkg^{-1}$ in the three layers whereas it was 130.3, 117.2 and 87.1 $mgkg^{-1}$ in the uncultivated soils (Table 5). The depletion in K content as compared to the initial status was observed in the short period of cultivation. Application of higher amounts of N and P fertilizers increased the demand for K by crops, which ultimately led to decline in K status. The data suggests that the fertilizer practices used in this region failed to build up or maintain the potassium status of the soil. It may be concluded that the K fertility status had declined due to higher rate of K uptake by the crops. The presumed relatively high K content in these soils led to the negligence of regular K fertilization. This finding were in agreement with Findley [28] who reported that K level in sandy loam soil declined where no K fertilizer was added. The data discussed here showed that depeltion of K mainly occurred after the short period of cultivation.

Micronutrients

The results presented in Table 5 show a slight increase in available Fe content in the first layer of the cultivated soils as compared to Fe status in the uncultivated soils. Increase in Fe status can be ascribed to either Fe addition via fertilization or as a contaminant through P fertilization. It was found that DAP contains 4050 mgkg-1 of Fe as a contaminant [29]. However Biswas and Benbbi [6] did not observe any appreciable change in DTPA- extractable Fe due to continuos cropping and P fertilization. Generally, these results indicated that the available iron values were low in the studied soil. However, its values were slightly increased due to cultivation.

Data given in Table 5 indicate a slight increase in the available Zn in the three soil layers as compared to the initial status in the uncultivated soils. These increases. However, were below the sufficient level as given by Soltanpour and Schwab [30]. The values reported in this study were even less than the values of zinc in some soil in the Kingdom as given by Mustafa, *et al.* [31] and Al-Jalud, *et al.* [32]. Nonetheless, increased zinc status in the fertilized soils can again be due to the addition of zinc as contaminant through P Source. Arora, *et al.* [29] found that on an average, superphosphate contained 165 $mgkg^{-1}$zn.

The available copper content in the cultivated soils increased from its initial average content of 0.40 to 0.59 $mgkg^{-1}$ in the 0-15 cm layer. Similar trend was observed in the second and third layers (Table 5). Results presented in Table 5 show that the increase in the Cu status was significant in the three layers only with long period of cultivation. The increase in Cu status of soil with continuous cropping can be ascribed to the same reasons as explained earlier for other micronutrients.

Regarding the effect of continuous cultivation on manganese status in the soil, data in Table 5 indicate a significant increase in the Mn status of the soil in the first layer under both periods of cultivation. But they were slightly changed in the deeper layers.
In conclusion, it may be stated that:

i) Long-term application of nitrogenous fertilizers (400-600kg urea ha^{-1}) did not result in large increases in the N status of the soil as would be expected. Therefore any excesses of N inputs represents a potential loss. Appropriate agricultural practices that could reduce N losses, without decreasing yield should be actively researched. Also judicious application of N fertilizer based on more knowledge of the different aspects of the nitrogen cycle should be implemented
ii) Since application of phosphatic fertilizers resulted in accumulation of NaHCO3-extractable P in the soil, it is expected that present level of P in the soil could provide adequate P for the succeeding crops and the fertilizer doses should be based on the P status of the soil.
iii) Use of K fertilizers is a must and should not be ignored.
iv) The soils in the studied area suffer from lower level of micronutrients. Thus micronutrients should be applied to obtain the highest possible yields.

Acknowledgement. This research has been financed by a grant made by SABIC (Saudi Arabian Basic Industries Corporation).

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تأثير التسميد المكثف لنبات القمح النامي تحت نظام الري المحوري على مستوى العناصر في بعض الترب الجيرية بالمملكة العربية السعودية

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(قدم للنشر في٢٧/١٢/ ١٤٢٠ وقبل للنشر في ١٨/١٢/ ١٤٢١ هـ)

ملخص البحث. اعتاد المزارعون في المملكة العربية السعودية على إضافة كميات كبيرة من الأسمدة الكيماوية دون مراعاة للأسس العلمية المتبعة في حساب الاحتياجات السمادية . لذا فقد اختيرت منطقة الخرج لتقييم مستوى الخصوبة في بعض تربها المزروعة بالقمح تحت نظام الري المحوري. تم تقييم مستوى الخصوبة في بعض هذه الترب ، لمعرفة تأثير تلك الإضافات على مستوى العناصر الغذائية في التربة. تم اختيار إحدى عشرة مزرعة تمثل فترتي زراعة طويلة نسبياً (أكثر من عشرة سنوات)، و قصيرة نسبياً (أقل من عشرة سنوات)، حيث تم جمع عينات تمثل ثلاث أعماق (صفر-١٥، ١٥-٣٠، و ٣٠-٤٥سم) من داخل الرشاش و خارجه.

أشارت النتائج إلى أن التسميد المكثف خلال فترة الاستزراع القصيرة يؤدى لزيادة معنوية في كل من النيتروجين و الفوسفور الميسر في العمق الأول فقط، بينما يمتد هذا التأثير للعمق الثاني خلال فترة الاستزراع الطويلة نسبياً وذلك بالنسبة للفوسفور فقط. كذلك أوضحت النتائج أن هناك زيادة معنوية في مستوى الزنك، والمنجنيز، و النحاس في التربة تحت فترتي الزراعة بينما كانت هنالك زيادة غير معنوية في مستوى الحديد.

بالنسبة لمستوى العناصر الكلية، فقد بينت النتائج أن الزراعة و التسميد لم يحدثا تغييراً معنوياً في مستوى النيتروجين الكلي. بينما حدثت زيادة معنوية في العمق الأول للتربة في مستوى الفوسفور الكلي وعلى العكس من ذلك حدث نقص في مستوى البوتاسيوم الكلي تحت فترة الزراعة القصيرة وذلك لإغفال التسميد به . تم استنتاج الوسائل الضرورية المطلوب اتخاذها لرفع كفاءة التسميد.