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Effect of Conservation Agriculture Practice on Yield, Nutrient Uptake and Off-Take of Wheat (*Triticum aestivum* L.)

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Abstract: Field trials were conducted at Nubaria, Behairah Governorate, Egypt, during two winter seasons 2017 and 2018 to investigate the effect of conservation agriculture through crop residue incorporation of four crop residues *viz.* (sesame, maize, sorghum and sunflower), on wheat as well as the nutritional status of wheat grains and soil properties. The result showed that sunflower crop residue improved wheat grain straw and biological yields compared to other crop residues. Macronutrient concentration in wheat grains were small, being below the levels normally recommended for optimum production, while micronutrient concentrations were adequate, except for copper which was low. Since the yields of the crop residue application significantly increased which means that the total off-take of these nutrients would be substantial. Aapplication of sunflower residue resulted in double uptake of the macro and micronutrients compared to the sesame crop residue application. Incorporation of sunflower residue resulted in the greatest off-take of N, K and all trace elements Fe, Mn and Cu of wheat crop and exceeded the other crop residue application; meanwhile, it took similar tendency of nutrient uptake of wheat grains. Although the effects of the crop residue application on soil parameters were not statistically significant, some trends for increasing EC, OM, nutrients were evident but it seems that application of crop residues had minor changes on soil properties and it is important to monitor changes in soil chemistry in the longer term. It may be concluded from this study that conservation agriculture through crop residue application to newly reclaimed soil is effective in improving crop productivity. It is unlikely that a single factor was responsible for this but is more likely to be due to the mixture of nutrients, micronutrients and organic matter that the residues supplies.

Key words: Conservation agriculture · Yield · Nutrient uptake · Off-take · Soil properties

INTRODUCTION

Conservation agriculture (CA) has been identified as an effective tool for sustainably increasing yields in many parts of the world [1, 2]. Conservation agriculture benefits both the environment and soil fertility [3] and it has different effects on crop production and nitrogen (N) use efficiency [4-7]. One of the main axes in (CA) is crop residue incorporation to the agricultural land. Application of conservation agriculture practices with residue retention has been found successful in maintaining sustainability in yield of various crops in Mexico and north-western India [8, 9]. Reicosky and Wilts [10] pointed out that crop residues have been referred to as 'wastes' but as a natural and valuable resource are also considered to be potential black gold. On the contrary of being a waste, crop residues offer a large, but finite potential mechanism for C sequestration and nutrient cycling. Crop residues are good sources of plant nutrients and are important components for the stability of agricultural ecosystems. About 400 million tons of crop residues are produced in India alone [11].

Since animal manure is no longer readily available, other materials such as crop residues should be tested and used to meet soil nutrient and organic matter requirements. Incorporation of crop residues is widely regarded as good practicable environmental option in controlling weeds due to the allelopathic effects of some crop plants [12].

Wheat is exhaustive crop it not only depletes soil fertility but also degrade soil physical properties. To overcome the problem of nutrient deficiency and increase wheat vegetation and yield, the farmers are applying chemical fertilizers [13]. The continued use of

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chemical fertilizers leads to a continued decline in soil quality and other environmental problems. For example, the application of nitrogen (N) fertilizers is proven to cause low N use efficiency (NUE) in crops and environmental pollution by the accumulation of NO_3–N in the soil [14, 15]. It was found that Wheat yields with (CA) practices are either equal or even better than those obtained with conventional practices because of timely planting of wheat, efficient use of fertilizers and weed control. In addition, (CA) is fuel and energy [16]. Incorporation of different crops residues into the soil had different effects on wheat growth and grain yield. The highest grain yield was significantly obtained when wheat was planted into the no residues in the first year and sunflower residues in the second year. Some investigators reported negative effects due to crop residues application and increased rate of all crop residues from 25 to 50% significantly decreased wheat grain yield. Akhtar *et al*. [17] indicated that among the crop residues 5 tons ha^{-1} of mungbean residues and 2.5kg ha^{-1} of humic acid delayed days to anthesis, days to maturity and improved plant height. Therefore they recommend to the farmers of Peshawar region that use mungbean residues at 5 tons ha^{-1} and humic acid 2.5 kg ha^{-1} for improved phenology of wheat in agro-climatic condition of Peshawar valley.

Therefore, the aim of this work is to study the effect of conservation agriculture through incorporation of some preceding summer crop residues on wheat yield, uptake and nutrient off-take of wheat crop and recycling some of the removed nutrients again to the soil.

MATERIALS AND METHODS

Field trials were conducted in the winter seasons of 2017 and 2018 to study the effect of crop residue incorporation *viz.* (sesame, maize sorghum and sunflower), on wheat yield, nutrient uptake and crop off-take as well as the soil properties in the newly reclaimed desert soils. The experiments were conducted in a private farm at Tawfiq El Hakim village (84 km Alex-Cairo desert road). The experimental design was Complete Randomized Block Design with four replications. Sowing of wheat was carried out in 29^{th} Nov and 25^{th} in 2017 and 2018 seasons respectively. Conventional tillage was applied as recommended in the district. Before sowing wheat (cv. Masr-1) the crop residues were spread at 2 ton fed^{-1} as copped residues (5-15 cm). Wheat was sown by drilling seed manually in rows at 15 cm apart at rate of 70 kg fed^{-1}. All plots were fertilized with the recommended doses of NPK and weeds were controlled by (hand pulling at 30 and 45 days after sowing, Harvesting was carried out during mid-May. After wheat harvest in each season yield and yield components were determined for each treatment and grain samples were taken to analyze macro and micro nutrients. Chemical analysis of the grains and the whole plant was carried out on dried and ground samples. Nitrogen was determined by micro-Kjeldahl according to [18]. After wet digestion of the samples, P was determined by spectrophotometry, K by flame photometer according to [19] and Fe, Mn, Cu and Zn were determined by atomic absorption spectrophotometry [20]. The nutrient uptake in grains was determined by multiplying grain yield by nutrient concentration while the off-take was determined by multiplying the biological yield by nutrient concentration in the whole canopy weight.

The analysis of variance of complete randomized block design was carried out using MSTAT-C Computer Software [21], after testing the homogeneity of the error according to Bartlett's test, combined analysis for both seasons was done. Means of the different treatments were compared using the least significant difference (LSD) test at $P<0.05$.

In this paper, for simplicity we will present only wheat yield data and nutrient content of grains as well as soil properties.

RESULTS AND DISCUSSION

Data presented in Table (1) show that there were significant differences in wheat grain yield due to the crop residue incorporated to the soil. Application of sunflower crop residue surpassed the sorghum without significant differences but it significantly affected wheat grain yield compared to the other sources (maize and sesame). Straw and biological yields took similar tendency and sunflower application surpassed the other crop residues in increasing either straw or biological yields. The yields generally were rather poor. The establishment of arable crops on newly reclaimed land can be variable due to the difficult soil conditions, particularly if seed is sown too shallow where it is more at risk of desiccation. The addition of the organic matter in the crop residues may assist in moisture retention and improved seedling survival. Applications of crop residues was found to increase wheat yields [6]. Also, they demonstrated that wheat (*Triticum aestivum* L.) grain yield was higher after green gram (*Vigna radiate* L.] *Wilczek*) compared with corn (*Zea mays* L.) used as a previous crop; this is associated with the fact that mineral N in the root-zone soil is often higher in a cereal-legume cropping system than in cereal monoculture. They added that crop residue incorporation increased wheat grain yield by 1.31 times and straw yield by 1.38 times, as compared with the control without residue incorporation, also [7] showed an increase of 12.0% and 3.5%, in wheat grain yield with residue incorporation without N application compared with the practices of removing or burning the residues. In addition, [22] indicated that straw incorporation increased rice and wheat grain yields by 11.6% and 11.1%, respectively, as compared with the same crops managed without residue incorporation. In contrast to the benefits indicated by different authors for residue incorporation, Limon-Ortega *et al.* [4] observed a decrease in grain yield of 0.2 Mg ha^{-1} in mono-cropping wheat when residue was incorporated instead of burning.

Data presented in Table (2) clearly show that except for N, Zn and Cu there were insignificant differences among treatments in their effect on nutrients in wheat grains. In general nutrient contents were small, being below the levels normally recommended for optimum production. Micronutrient concentrations were adequate, except for copper which was low. Since the yields of the crop residue application significantly increased which means that the total off-take of these nutrients would be substantial. Thus, in terms of plant nutrition crop residues are good source of macro and micronutrients for wheat.

Data presented in Table (3) and Figs. (1 and 2) show nutrient uptake of macronutrients N, P and K (g m^{-2}) as well as the micronutrients Fe , Mn , Zn and Cu (mg m^{-2}). The analysis of wheat grains indicated that incorporation of sunflower residue resulted in the greatest uptake of N, K and all trace elements Fe, Mn, Zn and Cu and surpassed the other crop residue application. It is worthy to notice that application of sunflower residue resulted in double uptake of the prementioned macro and micronutrients compared to the sesame crop residue application.

Data in Table (4) and Figs. (3 and 4) show wheat crop off-take of macro and micronutrients due to crop residue application. The analysis of wheat plants indicated that incorporation of sunflower residue resulted in the greatest off-take of N, K and all trace elements Fe, Mn and Cu surpassed the other crop residue application. It took similar tendency of nutrient uptake of wheatgrains.

Table 1: Effect of crop residue application on wheat yield characters

Crop residue applied	Grain yield fd^{-1} (t)	Straw yield fd^{-1} (t)	Biological yield fd^{-1} (t)
Sesame	1.18 b	2.96 b	4.14 b
Maize	1.37 b	3.91 ab	5.28 ab
Sorghum	1.70 a	3.45 ab	5.15 ab
Sunflower	1.88 a	4.35 a	6.23 a
Probability	<0.001***	0.047*	0.003**
LSD at 0.05	0.28	1.33	1.26

Values for each mean within a column, followed by the same letter, are not significantly different at P = 0.05

Table 2: Chemical composition of wheat grain (Units: macronutrients as %; other elements at mg kg^{-1})

Treatment	N	P	K	Fe	Mn	Zn	Cu
Sesame	1.55	0.20	0.54	317.0	38.3	44.8	4.52
Maize	1.75	0.17	0.58	360.9	45.1	61.2	3.36
Sorghum	1.55	0.22	0.50	333.9	43.9	46.8	5.49
Sunflower	1.80	0.18	0.49	356.2	44.7	48.0	5.66
LSD at 0.05	0.06	-	-	-		4.1	0.18

Table 3: Effect of crop residue on nutrient uptake by wheat grains (g m^{-2})

	Macronutrient uptake (g m^{-2})			Micronutrient uptake (mg m^{-2})			
Treatment	N	P	K	Fe	Mn	Zn	Cu
Sesame	4.35	0.56	1.63	89.06	10.76	12.59	1.27
Maize	5.71	0.55	1.89	117.72	14.71	19.96	1.10
Sorghum	6.27	0.89	2.35	135.15	17.77	18.94	2.22
Sunflower	8.06	0.81	2.60	159.44	20.01	21.49	2.53
LSD at 0.05	1.3	0.20	0.33	23.4	4.15	4.77	0.25

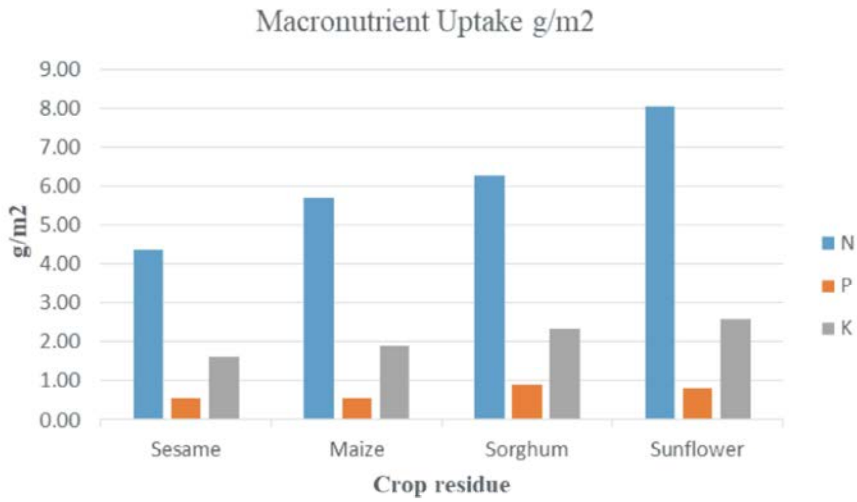

Fig. 1: Effect of crop residue on macronutrient uptake by wheat grains (g m^{-2})

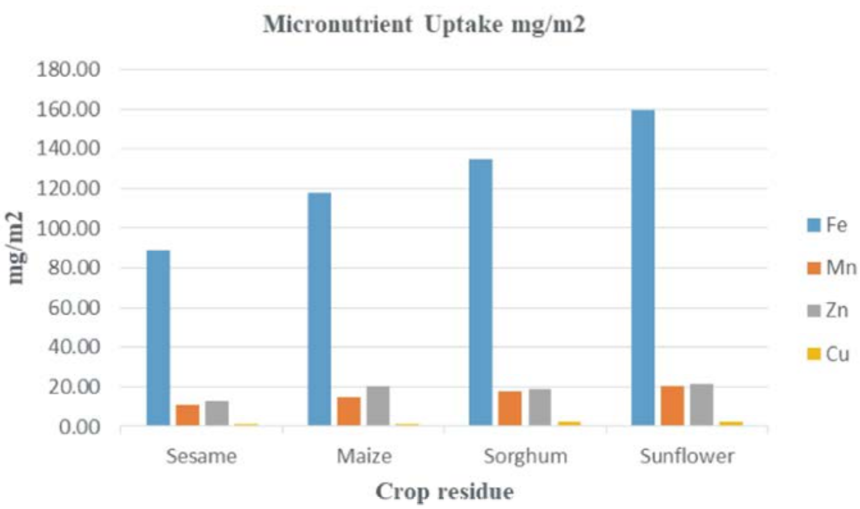

Fig. 2: Effect of crop residue on micronutrient uptake by wheat grains (mg m^{-2})

Table 4: Effect of crop residue on macronutrient off-take (kg fed^{-1}) and micronutrient off-take (g fed^{-1}) by wheat plants

	Macronutrient off-take (kg fed^{-1})			Micronutrient off-take (g fed^{-1})			
Treatment	N	P	K	Fe	Mn	Zn	Cu
Sesame	63.6	8.2	23.8	1299.7	157.0	183.7	18.5
Maize	92.6	9.0	30.7	1909.2	238.6	323.7	17.8
Sorghum	79.8	11.3	29.9	1719.6	226.1	241.0	28.3
Sunflower	112.1	11.2	36.1	2219.1	278.5	299.0	35.3
LSD at 0.05	22.1	ns	4.4	422.1	ns	66.0	7.3

Table 5: Chemical analysis of soil after wheat harvest; mean of two seasons (Units: EC as dS m^{-1}; OM as %; other elements as mg kg^{-1})

Treatment	pH	EC	OM	N	P	K	Fe	Mn	Zn	Cu
Sesame	8.04	0.22	0.71	1748	46.3	754	6381	85.2	12.7	3.9
Maize	7.83	0.25	1.19	1972	50.3	827	6432	87.4	23.6	13.5
Sorghum	7.77	0.27	1.24	2333	77.3	812	9021	116.2	33.7	20.2
Sunflower	7.76	0.25	1.17	2138	60.7	870	7120	94.7	28.2	15.5
LSD at 0.05	ns	ns	0.11	190	18	ns	ns	21.8	4.9	4.7

Values for each mean within a column, followed by the same letter, are not significantly different at P=0.05

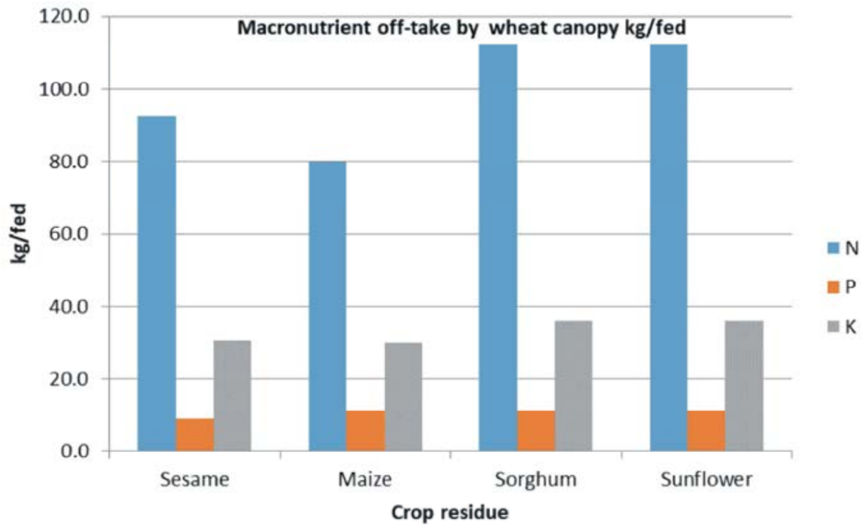

Fig. 3: Effect of crop residue on macronutrient off-take by wheat plants (kg fed^{-1})

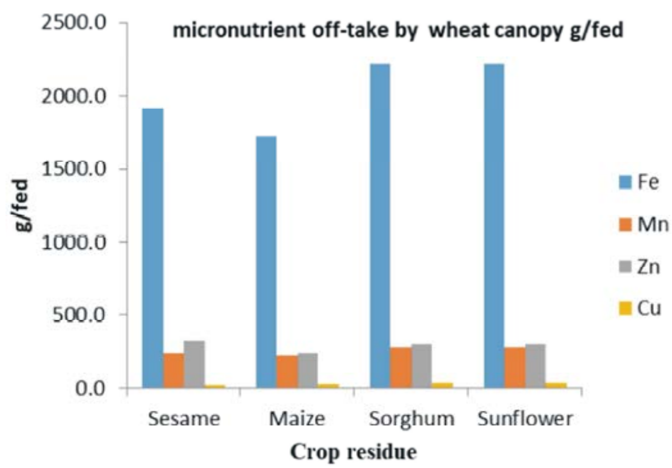

Fig. 4: Effect of crop residue on micronutrient off-take by wheat plants (g fed^{-1})

The literature on the effect of residue management on nitrogen (N) or phosphorus (P) uptake by plant is uncertain with no (for N: [23]; or positive (for N: [24] and for P: [25]) or negative effects reported by different authors (for N: [26]; for P: [27]). These differences are generally attributed to differences in soil texture and/or initial nutrient status or residue quality [28, 29].

Data presented in Table (5) indicate that While the effects of the treatments on soil concentrations were not statistically significant, some trends for increasing EC, OM, nutrients but it seems that application of crop residues for two seasons had minor changes and the continuation of this trial is important to monitor changes in soil chemistry in the longer term. Janssen and Whitney [30] reported that soil analyses after 11 years of residue fertilizer treatments indicated significant differences in exchangeable K, bulk density (data not shown) and organic matter due to residue treatments. There was a statistically significant interaction between the residue and fertilizer treatments for exchangeable K.

It may be concluded from this study that crop residue application to newly reclaimed soil is effective in improving crop productivity. It is unlikely that a single factor in crop residue was responsible for this but is more likely to be due to the mixture of nutrients, micronutrients and organic matter that the residues supplies.

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