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EFFECT OF MAIZE SUCCESSION WITH SOME WINTER CROPS ON SOIL NPK AND ORGANIC MATTER

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ABSTRACT

The research was carried out to estimate the effect of winter crops succession with maize on soil organic matter and N.P.K, at Grdarasha Agricultural Research Station, College of Agricultural Engineering Sciences, Salahaddin University, Erbil, Kurdistan region, throughout three seasons of 2016-2017 (two fall seasons and a winter season). During both fall seasons, the entire field was planted with maize and at winter season 2016-2017, three winter crops namely canola, chickpea and wheat were chosen as well as a fallow plot in randomized complete block design (RCBD) with three replications. The results of statistical analysis indicated that each of the winter crops performed their independent impacts on soil components with different quantity, in general, first season maize exhibited the most soil elements depletion role significantly, followed by wheat and chickpea. For instance, the lowest significant value of (soil organic matter, nitrogen and phosphorus) observed after each of the named crops with (0.35%, 0.27%, 2.50 mg kg^{-1}), (0.57%, 0.14%, 1.67 mg kg^{-1}) and (0.83%, 0.17%, 2.00 mg kg^{-1}) respectively, whereas potassium exhibited non-significant variations between the treatments. Regarding the highest values, maize of the third season accomplished the maximum significant value for organic matter with (1.78, 1.04, 1.09 and 1.23%) related to the huge vegetative portion of maize. Involving soil N 1.33% was the biggest significant value after canola, while the highest phosphorus significant value notice after maize that was subsequent to canola and wheat with 5.75 mg kg^{-1}.

Keywords: crop succession, soil organic matter, N, P, K.

Introduction

The employment of crop rotation and manure usage can supply sustainability for an agricultural output strategy by ameliorating soil quality and enhancing nutrient use efficiency (Steiner *et al.,* 2012). International food security is increasingly affected by descending soil fertility and the impact of climate variance (Wheeler and von Braun, 2013). Monitoring soil nutrients expeditiously to achieve maximum efficient crop production is a fixed dispute for rain-supply agriculture. Maize is an effective soil element consumer grown in various agro-ecological regions. Nonetheless, soil fertility decrement stays a universal difficulty influencing persistence cultivation of plants and thus restricting nutrition security. The consequence of nitrogen and phosphorus fertilizer usage at every sowing time differed with the weather circumstances, in connection with that, variations in ecological conditions and fertilizer amount affected the crop Development, physiological and productivity parameters evaluated significantly (Akinnuoye-Adelabu *et al.,* 2018).

In general, crop rotation boosts crop productivity and its constancy (Helmers *et al*., 2001). For example, crop successions with more contribution of cereals present a decreased production steadiness of wheat in compare with rotations involving legumes (Macholdt and Honermeier, 2017). Soil physical characteristics exhibited no significance statistically, pertaining the interaction between fall successions and winter crops (Santos *et al.,* 2019).

Amongst the cover crops, members of the Leguminosae family are the utmost broadly grown because of their capability of N fixation, biomass yield and their vitally important root structure; they have ability to receive soil components at lower zones (Fontaneli *et al*., 2012). In consequence, the farming strategy with Fabaceae plants is an effective plan to assemblage of total nitrogen in the soil superficial zone, for the corn nutrition and development (Oliveira *et al*., 2003).

Cereals and legumes competition for soil N is declined and maize takes more N from the soil than beans (Andersen *et al.,* 2005). In spite of a soil organic carbon proportion descend over time, which was particularly noticed throughout the first decade of the research, its amount was 7% greater in the lowest tillage treatment in comparison to the plough treatment, whereas crop rotation exhibited no significant impact. In 2016, crop succession and soil ploughing techniques together affected soil characteristics, the concentrations of nitrogen, phosphorus, potassium and other components were smaller in crop rotation in compare to uniculture (Carcer *et al*., 2019).

Phosphate fertilizers addition to calcareous soils for instance Iraqi soils established number of troubles chiefly

because of adsorption, precipitation and fixation processes on, or with clay minerals surfaces, carbonates, organic materials and calcium carbonate surfaces (Al-Harbi *et al*., 2013). In order to catch extra nutrients, root arrangements of maize and soybean possess structural and physiological flexibility to a focalized supply of P (Zhou *et al*., 2019). Numerous approaches and techniques have been utilized to develop or enhance the efficacy of phosphate fertilizers, which have been examined for lots of kinds of agricultural soils in their P availability to ascertain the suitable level of the plant and attain the maximum response in the development and productivity of the plant (Al-Kalaby, 2018; Pela *et al*., 2017; Van de Wiel *et al*., 2016). One of the methods that have the ability also ameliorate the effectiveness of phosphate fertilisers is the interaction of P with other elements. Numerous experiments pointed out that there is an interaction between P content and other nutrients. The helpful impact of interaction is increment in P accessibility or heighten the uptake in the plant or in biological and physiological actions. It was detected that the interaction of P with Mg had a positive consequence in the soil and plant, P has a positive influence on Mg inside the plant. Phosphorus promotes the production of energy for all biological activities, via its participation in the constitution and division of cells and root hair density, which intensified nutrient absorption involving Mg in addition to enhancing the straw portion that needs of Mg to chlorophyll establishment (Fageria *et al*., 2017). Referring the productivity improving, maize plant may possibly through the optimization of soil profile by crop rotation, deeper soil preparation and correction (Battisti and Sentelhas, 2017; Catuchi *et al*., 2012). Cropping system did not influence the total quantity of existing soil phosphorus in the first year of the study. When the second year finished however, the maximum amounts of phosphorus were noticed in soils with the crop succession technique exploitation, with these amplified phosphorus levels potential symbolizing a remainder impact of fertilization of the cash crops (Steiner *et al.,* 2012). Soil potential Hydrogen, nitrogen and potassium proportion had no significant variance between the control and the alterations post-harvest. Higher phosphorus significantly at 0.05 level referring to the control was found in S4 and S5 where maize was harvested (Rop *et al.,* 2019).

Nitrogen, phosphorus and potassium are the three principal macronutrients and unremarkably to the highest degree structure content of the fertilization plan. These elements are also required in the maximum amount by crops. Micronutrients are demanded in just detectable amount, though are only as crucial to plant growth and commercial crop yield in compare with the macronutrients (Havlin *et al*., 1999). Application of the nitrogen, phosphorus and potassium fertilizers in a balanced way may act a crucial important task in magnification the products of cereals under moisture stress condition. Amongst the restrictive factors, appropriate amount and ratio of nitrogen, phosphorus and potassium are of superior essentiality, nitrogen (N) in combination with phosphorus (P) and potassium (K) prominently affected the vegetative development and plant height of maize (Asghar *et al*., 2010).

Apparently, management of potassium has become extremely essential in maintaining or enhancing crop productivity in Asia now. Appropriate potassium (K) management needs a comprehensive understanding of soil potassium behaviour and of the diverse K inputs and outputs of cropping programs. It is famous that the conveniency of potassium to plants does not rely on the magnitude of the existing pool in soil alone, but also on the transfer of potassium K from soil solution to the root region and from the root region into plant roots (e.g. Barber, 1985). A lot of plant factors (variety, root structure, and antagonistic and synergistic procedures in ion consumption), soil factors (pH, OM content, texture, complementary cations) and ecological factors (precipitation, temperature) may influence these procedures. However, when the available soil potassium for the plant is adequate, these factors tend to become less essential. Consequently, preservation of soil potassium is a key factor to maintain and augment plant productions.

Depleted organic carbon (OC) and organic matter (OM) was belonged to small amount of organic materials inserted to the soil as plant remainders are entirely eradicate at harvest (Rop *et al.,* 2019). Organic matter carries out vital tasks in enhancing soil physical, chemical, and biological characters. It is conceived as a vastly essential parameter of soil fertility and yield. It furnishes nutrients to the soil, enhances water retention level and aids the soil to preserve more aeration and soil quality for seed germination and crop root growth (Ding *et al*., 2006, Oorts *et al*., 2003, Zia, 1993). Soil O.M. is thought to be a key impact of soil quality because of its influence on the chemical, physical, and biological attributes and activities in soils. On the other hand, it is not sensitive to short-term variations of soil quality with diverse soil or plant management procedures because of great background levels and natural soil variance, it has been proposed by (Magdoff and Weil, 2004, Haynes, 2005). Soil O.M. covers a multiplicity of organic compounds with decaying rates, which change continuously because of the complicated interactions of biological, chemical and physical activities in soils (Konare *et al*., 2010). It is familiar the magnitude of soil O.M. for soil quality and crop development. Therefore, numerous approaches have been suggested for its evaluation (Mebius, 1960, Walkley and Black 1934). The greatest technique for measurement of the organic matter is the wet (Walkley-Black) procedure instigate more precision (Khoshnaw & Esmail, 2020).

The objective of the study was to demonstrate the effects of winter crops succession with maize on some soil constituents such as N, P, K and organic matter.

Materials and Methods

The field experiment was conducted at Grdarasha Agricultural Research Station, College of Agricultural Engineering Sciences, Salahaddin University, Erbil, Kurdistan region during three seasons in 2016 and 2017 (two fall seasons and a winter season). Three winter crops were preferred: wheat (*Triticum aestivum* L.), canola (*Brassica napus* L.) and chickpea (*Cicer arietinum*), in addition to a fallow plot. In fall seasons of 2016 and 2017 all plots were sown to a homogeneous maize crop. During the winter season 2016-2017 the crops were sown in randomized complete block design (RCBD) concerning three replications. Each replication comprised of four plots (3 × 3) m. For each crop, all the cropping practices were applied involving sowing date, plant density, fertilization and irrigation whenever it was required. After all crops were harvested, the plots ploughed manually and separately to avoid soil mixture

among plots so that to be prepared for the fall season the similar technique was repeated after each growing season**.**

The soil chemical analysis experiment was carried out at laboratories of soil and water department, College of Agricultural Engineering Sciences, Salahaddin University. At the commencement of the experiment, soil sampled to 25 cm depth at five places in the experimental field covering all treatments and replications, using core sampler, afterwards, samples were mixed and bulked, a representative sample was drawn for chemical analysis for the following soil properties: nitrogen (N), phosphorus (P), potassium (K) and organic matter (OM) (Saunders and Williams, 1955). The soil samples were air dried, hand purified to remove foreign particles and ground to pass through a 2 mm sieve**.** After the harvest of each season, in the same way as described above.

The N percentage was determined by the Kjeldahl method (Bremner, 1996). Phosphorus concentrations was measured with a spectrophotometer that can detect the complex absorption at 882 nm (Olsen *et al.,* 1954). Potassium values were found through Flame photometer method.

The total organic carbon was detected by oxidation with a potassium dichromate-titration of $FeSO_4$ according to Walkley-Black Method (1947).

Results and Discussion

The effects of the crop succession on soil components especially N, P, K and OM were reported in table (1) and figure (1), statistical analysis indicated that each of the winter crops performed their independent impacts on soil components with different quantity, because of the diverse biology and growth of each crop introduced into the succession program. Regarding the organic matter percentage, canola residues was exhibited the maximum significant value (1.78%), the results of Sadalla *et al*. (2015) was in accordance to the present values which found that the organic matter was increased after both winter crops, for the reason that canola possesses a huge vegetative growth which led to heighten soil organic matter content, in addition, OM% was negatively correlated with nitrogen content. Concerning the lowest value, after maize 0.35% was the lowest value, because maize exhausted the mentioned content and fertilizer more vigorously, followed by the wheat with percentage of 0.57%, this ratio indicated that Poaceae family were consumed organic matter more than other exploited families, *i.e.* Leguminosae and Cruciferae, and the smaller volumes of straw were left after wheat, meantime compared with other crops achieved the lowest soil organic matter content ultimately. The results of Fontaneli *et al.* (2012) supported our results.

Pertaining the soil nitrogen mobilization, the results of the statistical analysis revealed that there were significant differences among treatments, for instance, the soil N% after canola which succeeded maize reported the highest value with 1.33% followed by the control with 1.06%. Considering the lowest nitrogen percentage, chickpea showed the lowest value, which was 0.11% due to the negative relation with potassium content. This result also indicated that prior to growth stage maize growth has already been affected by N deficiency in advance, afterwards the results pronounce the maize negative impact on soil nitrogen content, maize is one of the soil elements and fertilizer deplete crops, especially nitrogen percentage on account of the tremendous vegetative growth thereby depends obviously on soil N presence, similar results have been corroborated by (Andersen *et al.,* 2005).

In some instances nitrogen and organic matter scored direct relationships as in the treatment after canola with 1.33 and 1.05% respectively, also denoted after maize of the first season with 0.27 and 0.35% in ascending order.

Table 1: Effects of crop succession on soil N, P, K and OM.

Treatment	OM%	N%	P mg kg^{-1}	K mg kg^{-1}
a0 control	$0.64b^{c}$	1.06^{ab}	1.92^{c}	40.00^{a}
a1 (after maize succeeded control)	0.35^{c}	0.27^{c}	$2.50b^{c}$	44.67^{a}
a2 (after canola succeeded maize)	1.05^{b}	1.33^{a}	2.17^{c}	41.33^{a}
a3 (after chickpea succeeded maize)	0.83^{bc}	0.17^{c}	2.00^{c}	43.33^{a}
a4 (after fallow succeeded maize)	0.92^{bc}	0.58^{bc}	1.83^{c}	51.00^{a}
a5 (after wheat succeeded maize)	0.57^{bc}	0.14^{c}	1.67^{c}	44.00^{a}
a6 (after maize succeeded canola)	1.78^{a}	0.15^{c}	5.75^{a}	45.33^{a}
a7 (after maize succeeded chickpea)	1.04^{b}	0.11^{c}	4.83^{ab}	49.67^{a}
a8(after maize succeeded fallow)	1.09^{b}	0.36^{c}	5.42^{a}	48.67^{a}
a9 (after maize succeeded wheat)	1.23^{ab}	0.23^{c}	5.75^{a}	43.00^{a}

Focusing on the soil phosphorus content P $mgkg^{-1}$, the statistical analysis clarified that there were significant variations among the treatments, thus the maximum values was noticed after canola and wheat with 5.75 $mgkg^{-1}$ for both treatments, this increment was coincident with organic matter percentage. There were a positive correlation between organic carbon and phosphorus. By addition of organic carbon, availability of phosphorus increases due to chelating of polyvalent cations by organic acids and other decay products, and indirectly by action of microorganisms. Second point is mineralization of phosphorus from soil organic P (present in organic matter in soil) is different from added organic matter. Narrowing of C:P ratio with the application P-fertilizers will trigger the mineralization. Added organic matter on decomposition and mineralization releases P from the material itself. In the absence of fresh organic matter, the mineralization occurs in soil from soil organic P. In a study soil organic carbon up to 0.2% did not influence crop yield, between 0.2-0.6%, it influenced yield and reduced the fertilizer requirement.

Whereas the lowest phosphorus proportion was obtained after wheat with 1.67 $mgkg^{-1}$, elucidating that this crop was exhausted soil and fertilizer phosphorus particularly at anthesis growth stage due to the extreme demand for this soil component. Among the treatments soil P existed the vast content in plots beyond maize with the values of 5.75, 4.83, 5.42, 5.75 $mgkg^{-1}$ after maize which posterior canola, chickpea, fallow and wheat respectively. Whereas Sadalla *et al*. (2015) expressed that the available phosphorous decreased after maize, On the other hand, (Steiner *et al.,* 2012) stated that crop system did not affect the total amount of available soil P in the first year of the experiment. But by the end of the

second year however, the highest amounts of P were observed in soils under the crop succession system.

Regarding the soil potassium content, data directed to the statistical analysis established that there were no significant differences between the treatments, this may associated with that most of the instances potassium tends to fix with other nutrients, eventually leads K to be in unavailable manner for crops sufficiently, also (Steiner *et al.,* 2012) accomplished that in the crop rotation system, variation in nutrient source did not affect soil K availability in either year of the evaluation. Dealing with the largest potassium value, was 51.00 $mgkg^{-1}$ after fallow treatment, on the other hand, 40.00 $mgkg^{-1}$ was the smallest amount at the control treatment, followed by the canola with 41.33 $mgkg^{-1}$ verifying that canola is a member of Cruciferae family possesses a magnitude tap root system with vigorously and efficiently active to uptake soil components especially macronutrients. Simultaneously Carcer *et al.* (2019) detected lower concentrations of N, P and K in crop succession program compared with monoculture.

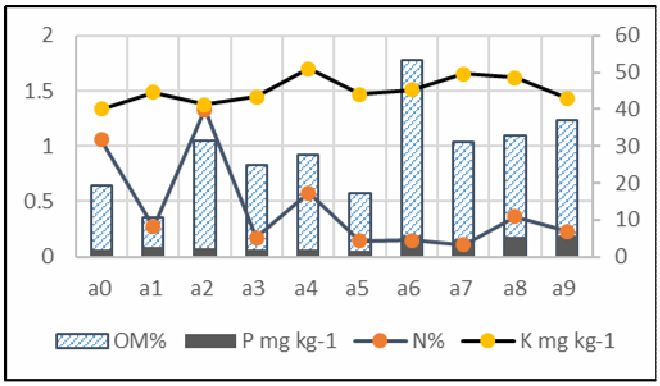

Fig. 1: effects of winter crops succession on soil organic matter and N.P.K

Conclusion

The study affirmed that winter crop succession with maize affected on the soil contents significantly, especially organic matter, nitrogen and phosphorus concentration except potassium. Therefore can be considered as a beneficial source of soil macro elements mobilization, regarding the organic matter, the sequence of maize- canola- maize gained the best significant result, whereas N% showed the highest value after maize- canola succession. Concerning the phosphorus soil content, also maize- canola- maize expressed the maximum value, illuminating that canola is one of the desirable crops which could be introduced to crop succession program. It can be concluded that treatments with canola and fallow achieved highest significant values for most studied soil contents. However, further studies are necessary to discover and qualify proper succession schemes with more winter crops to attain best soil contents mobilization and lessen the loss of crucial soil contents as possible as could.

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