EFFECTS OF ORGANIC FERTILIZERS AND WHEAT VARIETIES ON INFESTATION BY, CORN LEAF APHID, *RHOPALOSIPHUM MAIDIS* AND WHEAT THRIPS, *HAPLOTHRIPS TRITICI* AND THEIR PREDATORS

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ABSTRACT

A field trial has been conducted at the fields of Agriculture College/ Salahaddin University- Erbil in order to evaluate the addition of some organic fertilizers to some wheat varieties and their susceptibility to attack by both corn leaf aphid, *Rhopalosiphum maidis* and wheat thrips, *Haplothrips tritici* with their predators. Three types of organic fertilizers (livestock manure, poultry manure + plant compost & plant compost) in a rate of (10 m^3/ ha) and synthetic fertilizer (NPK) at (0.1 m^3/ha) were applied into the soil. There were significant effects of organic farming on decreasing the population density of both *R. maidis* and *H. tritici* in comparison with inorganic practices which recorded highest numbers (7.18 aphid/ tiller) and (2.84 thrips/spike) respectively, the Smito variety was more susceptible to attack by *R. maidis* than Rzgari variety, while more resistant to *H. tritici* in comparison with Rzgari variety. In addition, more predators, *Coccinella septumpunctata* and *Syrphus corolla* were observed in organic compost than in chemical fertilizer treatments and controls. The field trial indicated that organic treatments (especially livestock manure and poultry manure + plant compost) were effective as synthetic fertilizer and therefore similar biological and grain yields were obtained when using various fertilizer types that differ from untreated control which had lower agronomic parameters

Key words: Organic fertilizers, *Rhopalosiphum maidis*, *Haplothrips tritic*, Coccinillids, Syrphidae, wheat, Iraq.

تاثير الاسمدة العضوية واصناف الحنطة في الاصابة بحشرتي من اوراق الذرة، *Rhopalosiphum maidis* و ثربس الحنطة، *Haplothrips tritici* و مفترساتها

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المستخلص

تم تنفيذ تجربة حقلية فى حقول كلية الزراعة / جامعة صلاح الدين – اربيل لتقييم اظافة بعض الاسمدة العضوية إلى بعض اصناف الحنطة وتاثيرها فى الاصابة بحشرتي من اوراق الذرة، *Rhopalosiphum maidis* وثربس الحنطة، *Haplothrips tritici* ومفترساتها. استخدمت ثلاث انواع من الاسمدة العضوية (المواشي و خليط الدواجن مع مخلفات النبات و مخلفات النبات) و بنسب 10 م³ / هكتار و الاسمدة الكيميائية (NPK) بنسبة 0.1 م³ / هكتار حيث تم اضافتها الى التربة. اظهرت النتائج تاثيرات معنوية في انخفاض الكثافة السكانية لكل من من اوراق الذرة *R. maidis* وثربس الحنطة *H. tritici* عند استخدام الاسمدة العضوية مقارنة بالاسمدة الغير العضوية حيث سجلت اعلى قيم (7.18من لكل فرع) و (2.84 ثربس لكل سنبلة) على التوالي، وقد كان الصنف سميتو اكثر حساسية للاصابة ب *R. maidis* من الصنف رزكاري، بينما كانت اكثر مقاومة ل *H. tritici* مقارنة مع صنف رزكاري. اضافة الى ذلك لوحظ نسبة اكثر من المفترسات مثل *Coccinella septumpunctata* و *Syrphus corolla* في حالة معاملات الاسمدة العضوية مقارنة مع معاملات الاسمدة الكيميائية م ومعاملة المقارنة. واوضحت التجربة الحقلية ان معاملات الاسمدة العضوية (وبالاخص فضلات المواشي و مخلوط الدواجن مع بقاياالنبات) كانت مشابه في التاثير مع الاسمدة الغير العضوية ولهذا تم ملاحظة كميات متساوية من الحاصل الحيوي وحاصل الحبوب عند استخدام الاسمدة المتنوعة والذي اختلفت عن معاملة المقارنة.

الكلمات المفتاحية: الاسمدة العضوية، من اوراق الذرة، ثربس الحنطة، الدعاسيق، ذباب السيرفد، الكثافة السكانية، الحنطة، العراق

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INTRODUCTION

Wheat (*Triticum aestivum* L.) is the world's most important cereal crops that is broadly consumed in the developing countries and plays a significant role in economic stability throughout the world. Bread wheat is the key of raw material in the milling and the bakery industries while durum wheat is valuable source for bulgur and pasta products as well as in the bread-making industry (41).Low production of wheat is attributed to several factors, including microbial diseases and insect infestations. Insect include corn leaf aphid, *Rhopalosiphum maidis* (Fitch) is often considered the most significant pest limiting profitable wheat production (23). The infested leaves turn pale and wilt as the adults and larvae suck the plant sap which eventually results in poor crop yield. Another important pest is *Haplothrips tritici* (Kurdjumov) damages the grains, especially during the milk stage (13, 36). Damaged wheat is more susceptible to pathogen attacks and the grain and baking quality is reduced significantly which lead to decrease in the commercial value of the product (22). In addition, both insect species are major vectors of several plant diseases (17).Using chemical pesticides to combat these insects is relatively difficult and costly. Besides, the appearance of pest resistance can cause the wheat to be burned during the milk stage (12). In view of the destructive activities of wheat by insects, it is imperative to use fertilizers in order to obtain stronger crop that not only could withstand pest infestation but also achieve higher yields. Thus, one of the ways to increase crop yield is by enhancing soil nutrient content. Generally, nutrients that used to enhance agricultural productivity could be either in the form of organic materials such as poultry litter, livestock manure, plant compost or inorganic fertilizers such as the compound NPK (8). Use of inorganic fertilizer to increase yield has been found to be effective only for a few years, thus, requiring long-term use (27). Further, chemical fertilizers cause environmental hazards, such pollution by nitrate leaching and might increase pest populations (7). In recent years, organic farming has received great attention as promising alternative to chemical fertilizers. Organic matter has a high nutritional value, cheap, readily available, biodegradable products, less insect and disease infection and can encourage the presence of beneficial microorganisms which contribute to soil fertility restoration (30). Hence, the global tendency of producing healthy food has generated the need of conducting further examinations. Adequate information on the effect of organic amendment on crop and pests is not available in Kurdistan region which suffers from a shortage of organic matters in the soil content and estimated around 1-2% only (37). Due to the importance of wheat that planted in large areas and the whole cultivated area is estimated around 800,000 ha in 2015-2016. =In the light of the interaction between soil nutrient and insects, instructions for sustainable crop production system can be provided (3). Therefore, the goal of this study is to evaluate wheat crop responses to infect by aphids and thrips with the predation effect of ladybirds and hoverflies under both organic and inorganic soil amendments were estimated. Further, the influence of organic manures in the form of livestock, poultry and plant compost with NPK as synthetic fertilizers on wheat biological parameters and yield has been explored. In addition, comparison between bread and durum wheat varieties with different nutrient applications was carried out in relation to population density of insect pests and their natural predators.

MATERIALS AND METHODS

Field study: A field experiment was conducted at (Girdarasha field station) of Agriculture College, Salahaddin University, Erbil, Iraq. Two wheat varieties (Smito, durum wheat and Rzgari, bread wheat) were obtained from Erbil Agriculture Research Centre (EARC) that based in Ankawa province. Germination percentage was evaluated for the seeds in petridishes in the laboratory. Wheat seeds were sown in the first week of January at a rate of 150 kg/ ha. An area of (12 x 42) m was dedicated for the experiment with net plot size of 2 x 1.50 m^2 (45g seeds / plot). The trial was laid out under Randomized Complete Block Design (RCBD) in three replications with having 3 m distance between treatments to avoid possible shift of insects during the study. The treatments encompass both synthetic and natural fertilizers that mixed with the rhizosphere layer of the soil in each single plot. In addition an untreated control maintained with no fertilizers (Table 1). No insecticides were applied during the study and field surveys were conducted weekly in the field.

Table 1: Nutrients used in the wheat field experiment

No.	Treatments	Application (t/ha)	Source
1	Inorganic compound (NPK) (15:15:15) used by (10)	0.1	EARC
2	Organic matter (livestock manure)	10	Girdarasha field station
3	Organic matter (mixed of poultry manure + plant compost) (2:1)	10	EARC
4	Organic matter (plant compost)	10	Local market
5	Untreated (control)	0	_

Experiment 1: Effect of various treatments on insect occurrence

Weekly data of leaf corn aphid, *Rhopalosiphum maidis* (Fitch) and wheat thrips, *Haplothrips tritici* (Kurdjumov) were recorded on wheat varieties in the early morning of each weak starting from the 4th week of February when the aphid population appeared untill the 3rd week of April when the thrips population was no longer present in the field. Aphids were recorded from tillers by randomly selecting 10 plants in each treatment and counting all *R. maidis* irrespective of their size and stage (23). Hence, overall 300 plants were examined each week and individuals collected were placed on a white tray. Whereas, *H. tritici* were collected on wheat spike from the ten plants in the same manner and samples within each plot were placed inside tight polyethylene bags that contain labels written on it nutrient types, wheat variety, replicate number and date (28). Samples were carried back to the laboratory for further examination as well as species identification under a stereo-scoped dissection binocular microscope connected with a digital camera UCMOS series (China) (11).

Experiment 2: Effect of various treatments on predator density Predators were collected from the field in weekly intervals in early morning usually during 7:00-11:00 am and the enumeration of (larvae and adults) of both *Coccinella septumunctata* (Linnaeus) and *Syrphus corolla* (Fabricius) was accomplished on all plants in each plot via utilizing aspirator, suction traps, beating the plant to dislodge larvae and adults and sweep nets. Thus, the total number of individual species was inspected thoroughly in both soil surface and plants within various treatments (14, 25).

Insect samples were classified using identification used by keys by (15, 17, 42) and those that needed reconfirmation were identified by expert taxonomist in the department.

Experiment 3: Effect of various treatments on biological parameters of wheat

In addition to population density of insects on wheat, data on plant height were recorded before harvesting by selecting 10 plants randomly in each treatment replication. Further, to investigate the influence of various treatments on wheat biological yield, specific square 1m were designed for the measurements and the harvested crop within each plot were weighed separately. Afterward grains were separated from the rest of plant and total grains in each spike measured using method by (32) as the following:

$$\text{Seed No /spike} = \frac{\text{No. of grains in each treatment}}{\text{Total No. of spikes}}$$

Further, the weight of 1000 grains of every plot was evaluated and their weights were compared via using sensitive electronic balance to an accuracy 0.001 mg (19). Likewise, total grain yield of each plot was assessed and the percentage efficiency of each treatment in accordance to their productivity (grain yields) was determined by (16) via using the below equation:

$$\%\ \text{Efficiency} = \frac{\text{Fertilizer treatment} - \text{Control}}{\text{Control}} * 100$$

Statistical analysis----Data were analyzed using Factorial analysis of variance (ANOVA) in Statgraphics Centurion XV followed by Fischer's least significant difference (LSD) test to determine statistical differences between means at P ≤ 0.05. Results are from backwards stepwise multifactor ANOVA. Regression analysis was performed to determine the relationship between climatic factors and insects. Data were square root transformed to minimize the variability and achieve normal distribution (40).

RESULTS AND DISCUSSION

Experiment 1: Effect of various treatments on insect pest occurrence: *Rhopalosiphum maidis* incidence was significantly influenced by wheat plants being grown on natural or chemically fertilized soils ($F_{(4,179)}$ = 38.01., P <0.001). The highest corn leaf aphid population was recorded on NPK fertilizer (7.18/ tiller), and the lowest numbers were documented on livestock treatment (3.25, Figure 1A). Likewise, wheat varieties significantly influenced aphid incidence ($F_{(1,78)}$ = 61.61, P <0.001). However, there was no significant interactions between treatments and wheat varieties ($F_{(4,177)}$ = 1.09, P =0.37).

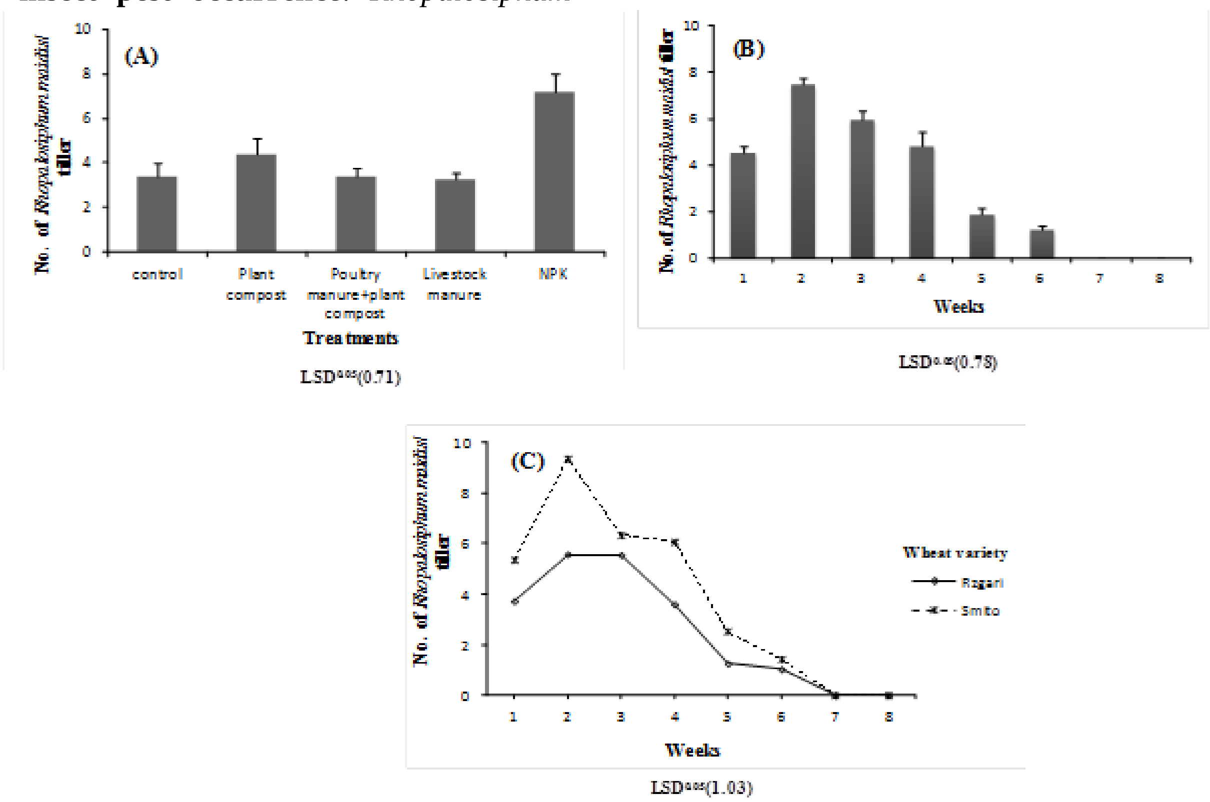


Figure 1: The incidence of *R. maidis* on wheat crop in relation to (A) fertilizer types (B) sampling dates (C) interaction between time and wheat varieties. Note: data taken for the first week corresponds to last week of February then sampling process was continued in regular weekly intervals

The results indicated that sampling date had significant influence on aphid numbers ($F_{(5,176)}$ = 103.31., P <0.001, Figure 1B), and also had considerable impact on aphid numbers via interaction with wheat varieties ($F_{(5,175)}$ = 2.67., P =0.02, Figure 1C). Hence, maximum average number of *R. maidis* individuals was observed on Smito variety during first week of March when the temperature starts to rise (Table 2) and lowest in the second and third weeks of April when the individuals start to disappear completely from wheat varieties (Figure 1C). The simple correlation coefficient analysis revealed that temperature had a relatively positive relationship (r =0.49, P =0.12) with aphid population while, relative humidity was not significantly (r =-0.21, P =0.48) correlated the numbers during vegetative state of the crop. No significant interactions were observed between weeks and fertilizer types ($F_{(20,174)}$ =7.47., P =0.08) or between the three main factors in the experiment ($F_{(20,173)}$ = 1.06., P =0.39).

Table 2: Weekly averages of temperature and relative humidity (R.H.) of Girdarasha field station 2016 from Ministry of Agriculture and Water Resources

Period/ months	Weeks	Average Temp (C°)	Average R.H. (%)
February	1	–	–
	2	–	–
	3	–	–
	4	12.83	76.53
March	1	16.14	33.93
	2	15.58	31.35
	3	12.04	38.89
	4	14.05	42.45
April	1	13.58	42.86
	2	18.8	57.76
	3	20.34	54.94
	4	–	–

The population density of *Haplothrips tritici* was significantly influenced by the the main factors (fertilizer type & sampling date) in the experiment ($F_{(4,149)}$ =6.71., P <0.001, Figure 2A ; $F_{(1,147)}$ =107.81, P <0.001, Figure 2B) respectively. There were significant interaction terms between wheat variety and nutrient type ($F_{(4,146)}$ =5.88, P <0.001, Figure 2C) and also wheat variety and sampling date ($F_{(3,145)}$ =40.46, P <0.001), with peak population (8.77 & 5.53/ spike) were recorded on week six for both Rzgari & Smito varieties respectively (Figure 2D). Whereas all other interaction terms between the main effects were not significant. On the other hand, both average temperature and average relative humidity displayed weak trend to thrips population with negative correlation coefficient values (r =-0.23, P =0.37)(r=- 0.13, P =0.51) respectively which were not statistically significan

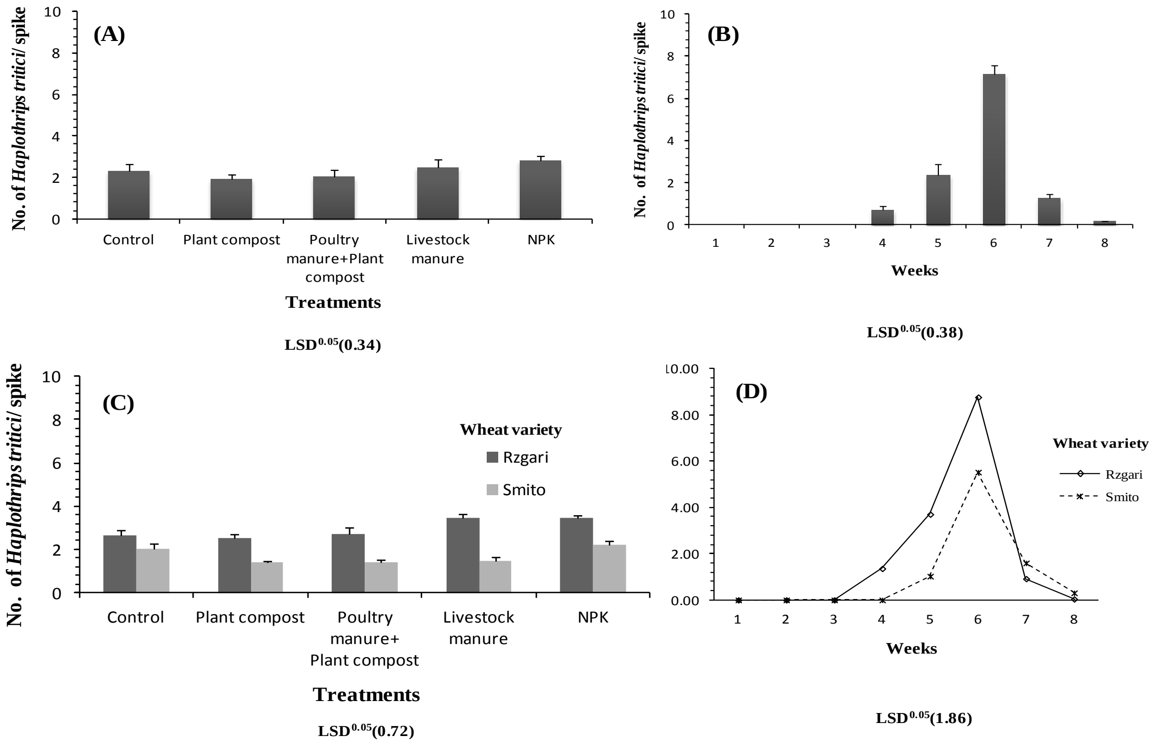
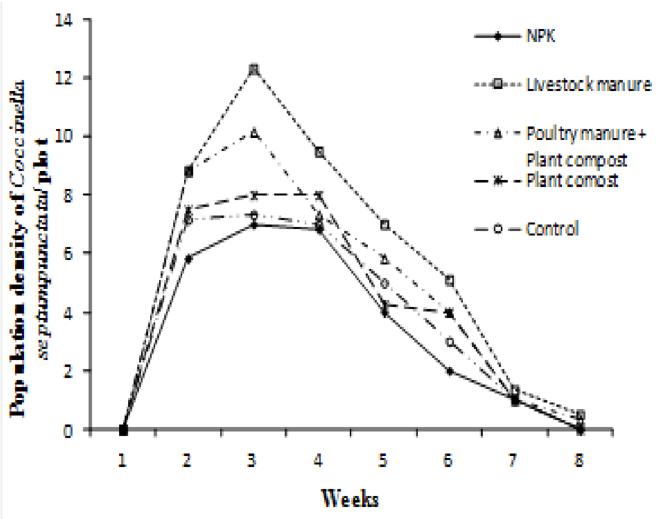


Figure 2: Population density of *H. tritici* on wheat crop in response to (A) fertilizer types (B) sampling date (C) interaction between fertilizer types and wheat varieties (D) interaction between sampling date and wheat varieties

The population density of both *Rhopalosiphum maidis* (Fitch) and *Haplothrips tritici* (Kurdjumov) were higher in synthetic fertilizer than in organic grown wheat and this may be due to the use of rapidly soluble minerals (e.g. N, P & K) that increase its acceptability as a food source to pest populations and also because of the reduced function of biological control agents in chemically fertilized crops (3, 33). On the other hand, plants would be expected to be less susceptible to insect pests and diseases if organic soil amendments were used because it can induce systemic resistance in plants via improved soil quality, growth and quality of the crop. Several reports indicated that soils amended with organic practices have enhanced resistance of various crops against insect pests and diseases (26, 31). Hence, organic nutrients not only affect the amount of damage that plants receive from herbivores but also the ability of plants to recover from herbivores. Regarding the influence of wheat variety on the occurrence of *R. maidis* and *H. tritici* population, the Rzgari variety was more resistant to corn leaf aphid infestation than the Smito variety. This might be due to cultivar preferences by the insects and the suitability of average temperature and moisture during first two weeks of March and later started to decrease in numbers when temperature decreased. Cereal aphid populations are expected to benefit from higher temperatures (38). On the other hand, relative humidity was negatively correlated with aphid populations (43). In addition, the *R. maidis* population starts to disappear from the field at the end of April probably to; individuals moved to other crops because of lack of sufficient vegetative parts as the wheat crop matured or were consumed by *C. septumpunctata* (Linnaeus) and or *S. corolla* (Fabricius) predators (24). Results obtained by (5 and 43) have also support my findings that aphid population reached its peak around the mid of March whereas minimum population numbers were recorded during April when the population in wheat crop starts to decrease significantly. Moreover, the Rzgari variety was more susceptible to ear- colonizing thrips, *H. tritici* than was the Smito variety. This might refer to the early ripening wheat ears of Rzgari in comparison with Smito variety. Similar to my findings, previous studies have found that variation losses due to aphids and thrips in wheat crop were depended upon wheat varieties (5, 18). However, both varieties showed similar trends towards thrips population within various weeks with peak numbers of individuals at the second week of April and their population was reduced when crop moved toward the harvesting stages (1). Further, the result revealed that thrips density was weakly and negatively associated with both temperature and humidity. According to 34, thrips populations were negatively correlated with both aforementioned environmental factors. Nonetheless, both average temperature and relative humidity were not significantly correlated (p> 0.05) with the population of insect pests in this study.

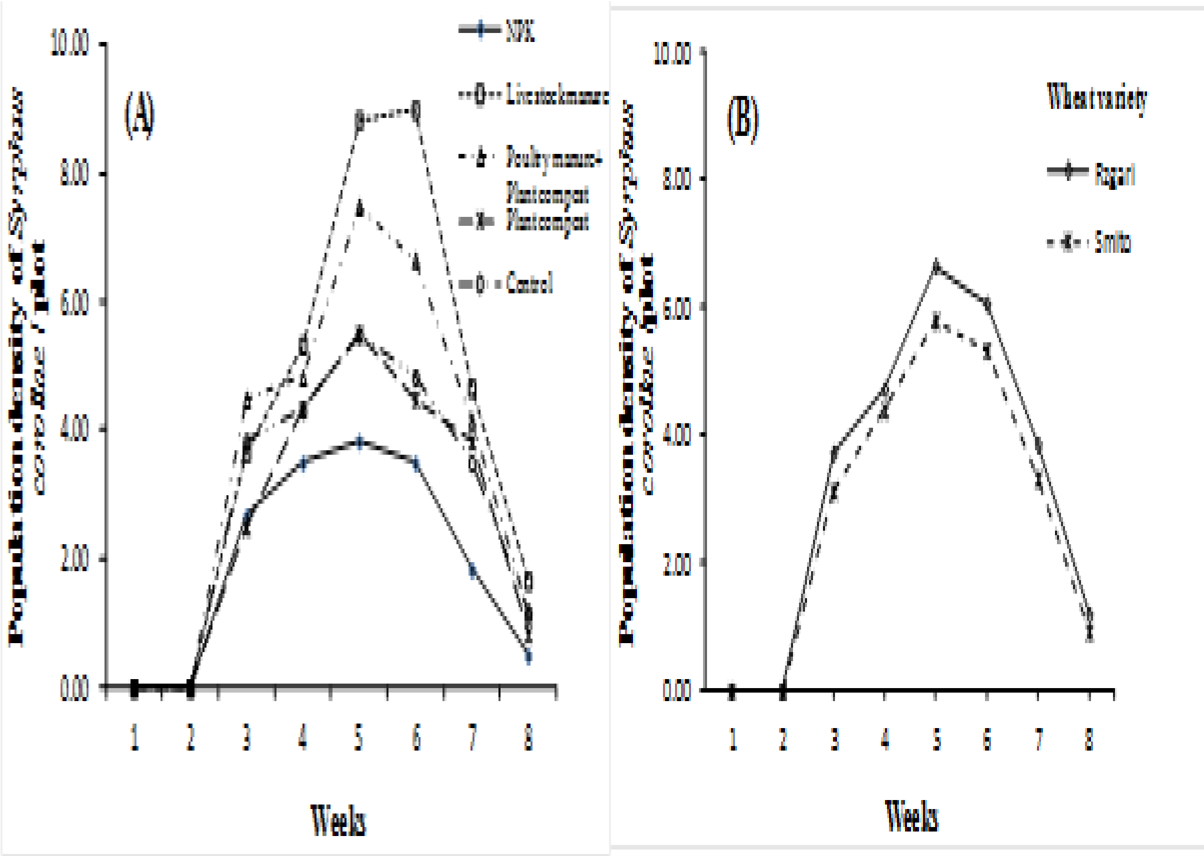
Experiment 2: Effect of various treatments on predator density The numbers of seven spotted ladybird significantly influenced by whether wheat crop were grown on conventional or organic soil ($F_{(4,239)}$ =38.17, P <0.001). The sampling date had significant impact on the density of *Coccinella septumpunctata* ($F_{(4,238)}$ =472.93, P <0.001). There were also significant interactions between treatment type and sampling dates ($F_{(28,237)}$ =5.73, P <0.001) with highest mean numbers (12.33) on livestock manure during third week of sampling date that equivalent to 2nd weeks of March which the numbers gradually decreased afterwards untill reached (0.5) during the 8th week of data recording (the 3rd week of April) (Figure 3). Wheat variety did not have a significant impact on ladybird population either alone or ($F_{(1,236)}$ =2.84, P =0.36) or via interaction with both fertilizer types ($F_{(4,235)}$ =6.45, P =0.93) and sampling dates ($F_{(7,234)}$ =3.89, P =0.99).



LSD0.05(1.26)

Figure 3: Population density of *C. septempunctata* on wheat crop in response to the interaction between fertilizer types and sampling dates

Population density of hoverfly, *Syrphus corollae* showed variation in abundance due to treatment application ($F_{(4,239)}$ =139.16, P <0.001), with maximum numbers were recorded on wheat grown on soil amended with livestock manures. Furthermore, the density *S. corollae* was significantly affected by either the interaction between weeks and treatment types ($F_{(28,236)}$ =18.22, P <0.001, Figure 4A) or between weeks and wheat varieties ($F_{(7,235)}$ =3.06, P =0.04, Figure 4B), with maximum numbers for both varieties during the 5th week which corresponds to the last week of March.



LSD0.05(0.87) LSD0.05(1.13)

Figure 4: Population density of *S. corollae* on wheat crop in response to: (A) interaction between fertilizer types and sampling dates (B) interaction between wheat varieties and sampling date

The number of predators was actively associated with the number of pests. Thus, aphid population and coccinellid predators fluctuated with the same trend and as aphid population increases, at the same time biocontrol agents like *C. septumpunctata* also increase positively as dominant natural enemies of this pest in wheat fields and their population was reduced when the host disappeared and the crop moved toward the harvesting stages (2, 23). In addition the hoverflies are efficient predators in cereal crops on aphids (25). The population of *S. corellae* appeared in wheat field after *C. septumpunctata* and assisted in the reduction of cereal aphid population growth. Multiple enemy species may act synergistically on their shared prey (39). Although the numbers of *R. maidis* & *H. tritici* were higher in chemically fertilized treatment fewer *C. septumpunctata* were observed, while the opposite result found for the organic treatments. Also, wheat fields treated with organic fertilizer hosted more hoverflies than wheat grown in synthetic fertilizer counterparts and their numbers increased proportionally with the application of natural nutrients. Numerous studies have reported that higher levels of natural enemy biodiversity and their abundance are associated with organic farming practices (26).

Experiment 3: Effect of various treatments on biological parameters of wheat

Both recycled organic wasted and conventional fertilizers influenced various agronomic properties of wheat. Biological yield significantly affected by nutrient applications ($F_{(4,29)}$ = 4.49, P = 0.009). Thus, highest total biomass was (5645.83 kg/ha) recorded by NPK that significantly differs from untreated control (3370.83 kg/ha, Figure 5A). Total biomass was not affected by whether durum or bread wheat was grown ($F_{(1,28)}$ = 2.78, P = 0.111) nor was there an interaction between wheat varieties and fertilizer types ($F_{(4,27)}$ = 2.36, P = 0.088).

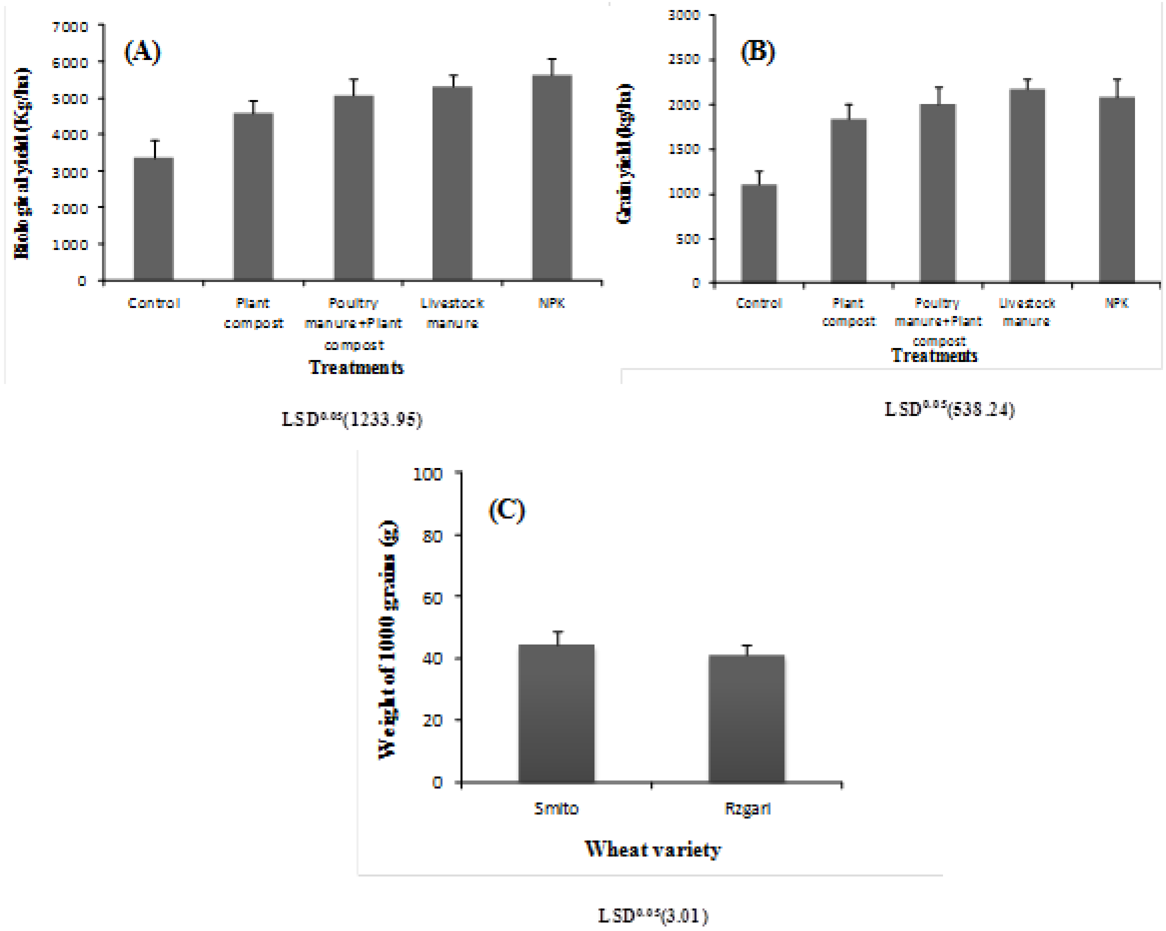


Figure 5: Influence of soil amendments with organic and inorganic fertilisers on (A) wheat biological yield (B) grain yield (C) influence of durum and bread wheat on the weight of 1000 grains

Treatments	Biological yield(Kg/ha)	Grain yield (Kg/ha)	Wt of 1000 grain (g)	Plant height (cm)	No. of grains in a spike	% Efficiency

Table 3: Yield and yield parameters of wheat crop under different treatments

NPK	**5645.83**	**2080.17**	**43.71**	**89.98**	**33.28**	**89.01**
Livestock manure	**5316.67**	**2175.67**	**45.18**	**93.36**	**33.36**	**97.69**
Poultry manure+ Plant compost	**5075.00**	**2010.67**	**44.75**	**88.38**	**27.89**	**82.70**
Plant compost	**4600.00**	**1834.46**	**41.93**	**85.64**	**25.99**	**66.69**
Control	**3370.83**	**1100.54**	**39.05**	**83.40**	**24.76**	**0**
Average	**4801.67**	**1840.3**	**42.92**	**88.15**	**29.06**	**-**
LSD	**1233.95**	**538.24**	**5.92**	**4.95**	**8.28**	**-**

Organic and synthetic fertility amendments resulted in an increase of grain yield ($F_{(4,29)}$ = 5.60, P = 0.003) and both types differs significantly from untreated control that has lowest grain yield (1100.54 kg/ha, Figure 5B). Further, highest percentage efficiency (97.69, Table 3) was recorded by the livestock manure followed by the NPK fertilizer. Varieties do not have impact on grain yield ($F_{(1,29)}$ = 1.13, P = 0.30) and there were no significant interaction between the fitted main effects ($F_{(4,29)}$ = 1.24, P = 0.33). The weight of 1000 grains was not significantly affected by the types of soil nutrients ($F_{(4,29)}$ = 2.06, P = 0.123) or by an interaction between fertilizers and wheat varieties ($F_{(4,29)}$ = 0.99, P = 0.438). However, was affected significantly by wheat varieties ($F_{(1,29)}$ = 6.05, P = 0.023), Thus, the weight was (44.54 g) for Smito and (40.91 g) for Rzgari variety (Figure 5C). Soil amendments did not have significant effects on the number of grains in a spike, hence neither fertilizer type ($F_{(4,29)}$ = 2.17, P = 0.11) and wheat variety ($F_{(1,29)}$ = 3.31, P = 0.083) nor interaction term between main factors were significant ($F_{(4,29)}$ = 1.09, P = 0.39). Though, the overall ANOVA analysis indicated that average number of grains/spike of the nutrient types did not vary significantly, both livestock and NPK fertilizers were productive with more than 33 grain/spike that differ from untreated control (Table 3). Wheat plant height was positively influenced by nutrient application ($F_{(4,29)}$ = 5.26, P = 0.005). Livestock manures recorded the highest plant height (93.36) that didn't differ significantly from NPK fertilizer (89.98, Figure 6A). Regarding wheat varieties, soft wheat significantly differs from durum wheat ($F_{(1,29)}$ = 125.94, P <0.001, Figure 6B), though no significant interactions between the fitted terms were observed ($F_{(4,29)}$ = 1.31, P =0.302).

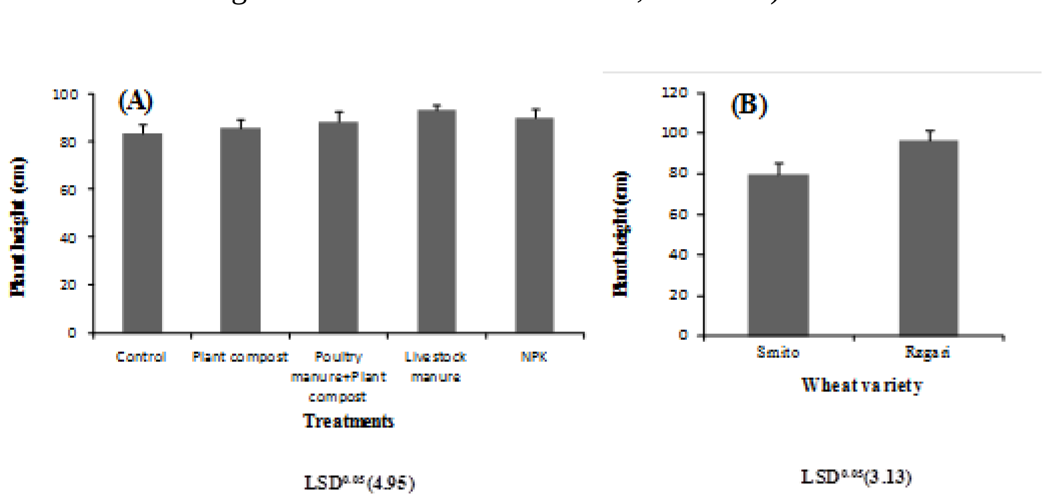


Figure 6: Plant height measurement in response to: (A) soil amendments with organic and inorganic fertilisers (B) wheat varieties

Soil health is the key into producing good yields of crops and the organic matter builds humus and food for soil which ultimately positively affects the agronomic parameters of a wheat crop. Thus, alternative soil amendments can enhance biological parameters of the crop due to the fact that recycled organic wastes would improve physical and chemical properties of soils profoundly (i.e. via pH reduction, bulk density, water permeability & total porosity) that increases the availability of soil nutrients for the plants (29, 35). Furthermore, organic manure activates many species of living organisms, which release phytohormones and may stimulate absorption of numerous nutrients (4). In this study, field soils on organic farms were productive as much as fields with conventional fertilizers probably because the decomposed organic matters (e.g. poultry, plant & livestock) stimulates microbial activity which leads to improvement in restoration of the natural health of the soil and an increase of plant yield (9). Different yield parameters (i.e. total biomass, grain yield, weight of 1000 grains & plant height) of wheat crop increased significantly with the use of organic matter especially the livestock manure and the combination between poultry and plant compost treatments which recorded higher percentage efficiency in response to their productivity. The improvement in these parameters of yield contributed towards an increase in yield of wheat crop which is the ultimate task of farming in order to increase income. Furthermore, weight of 1000 grains and plant height were affected by wheat cultivar. Results obtained by prior studies (21) concur with these findings. Besides, the mass of 1000 grains often is used as an indicator for the seeds size which ultimately seeds with bigger size would provide better developed and more resistant plants (20). Results obtained in this study are in agreement with many other previous findings which indicated that adding organic matter into soil results in increased plant yields, such yields equals those of synthetic production systems (29, 35) or can even exceed them (26, 30).

Chemically fertilized wheat was more susceptible to insects compared to organically grown wheat, especially in terms of population density of piercing sucking insects (e.g. aphida and thrips), which affects crop quality. Hence, approximately similar yields were obtained under recommended chemical fertilizer and natural nutrient treatments. Chemically fertilized wheat would probably be of lower quality, whereas the untreated control attained the lowest yield. Further, inorganic fertilizers generally attracted fewer predators to wheat plants compared to the organic manures. Thus, one of the ways to improve the quantity and quality of crops would be by boosting its nutrient content with organic matter which not only improve the yield but also reduces pest infestation, production costs and environmental pollution.

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