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Compost fortification with lignocellulolytic fungi for wheat cultivation using fewer mineral fertilizers amount in sandy soil

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ABSTRACT

Current study has focused on the hypothesis that augmentation of organic fertilizers with lignocellulolytic fungi could overcome the slow-release issue of nutrients and act as plant growth-promoting fungi (PGPF) for plants against synthetic fertilizers. Two factorial experiments were implemented to study the influence of compost, processed by the addition of lignocellulolytic fungi, against rates of NPK fertilizers on the growth and productivity of cultivated wheat in sandy soil. An inoculum consisted of two cellulolytic fungi, viz *Trichoderma harzianum* and *Trichoderma viride* and a ligninolytic fungus, viz *Phanerochaete chrysosporium,* was used for processing the compost before sowing. Three rates of NPK fertilizers, viz 100%, 75%, or 25% of the recommended dose were combined with processed compost or unprocessed. The results revealed an intensification of overall microbial count and associated activities in the rhizosphere of plants due to processed compost and a medium dose of NPK fertilizers. The dry weight of shoot generally increased in order 100% NPK> 75% NPK > 50% NPK, with a non-significant difference between 100% and 75% treatments when combined with processed compost. Despite the superiority of the full dose of NPK treatment, the divergence between them and 75% NPK fertilizers appeared non-significant when combined with processed compost for straw and grain yield, the weight of 1000 grains, or crude protein. Under the current situation, empowerment to diminish the applied amount of synthetic NPK fertilizers by 25% from the total dose by the incidence of saprobic fungi for more decomposition of organic matter doing a positive priming effect in wheat rhizobiome acting to improve the above- and below-ground parts of plants as a source capacity for high grain yield in eco-friendly and sustainable sound.

Keywords: Wheat growth and productivity, Saprobic fungus, Mineral fertilizers, processed compost, Priming effect.

INTRODUCTION

Wheat (*Triticum aestivum*) is a chief staple crop for Egypt. Because it is not attained self-sufficiency in wheat production until now, Egypt is one of the largest wheat importers worldwide to be about 10.5 million metric tons per year. Meanwhile, as reported by FAO (2021), the wheat production in Egypt amounted to approximately nine million tons as a product of about 6.57 tons per hectare and about 1.4 million hectares of harvested area. Egypt targets to reclaim the sandy desert soils for expansion in arable land located in the arid zone characterized by a scarcity of water, un-favorable soil properties and nutrients deficiencies which represent the most constraints confronted by any agricultural project proposed (Eissa *et al.*, 2014).

Globally, a greater focus on applying synthetic fertilizers has been the primary approach to offset soil nutrient depletion. Such application usually deviated to over-fertilization as in Egypt, which recorded an increment in total consumption of mineral fertilizers year by year to attain in 2019 about 1,245, 223 and 125 thousand tonnes of N, P, and K fertilizers as N, P_2O_5, and K_2O, respectively, according to FAO (2021) that documented such consumption as an over-fertilization. Therefore, the Egyptian soils have been managed in a way that potentially achieves maintenance and improvement of the current fertility, taking in mind sustainable land usage through the integration between synthetic, organic, and bio-fertilizers as well as the nano-fertilizers (El-Ramady *et al.*, 2019). Matching crop nutrient requirements, fertilizer additions, and minimizing nutrient losses from fields are some of the "Best Management Practices" (BMPs) which ultimately developed the concept "4R Nutrient Stewardship" for applying nutrients taking in mind “Right Source”, “Right Rate”, “Right Time”, and “Right Place” (Johnston and Bruulsema, 2014).

The process of nutrients released from fertilizer ingredients to be accessible in the soil in adequate and balanced amounts for optimal plant development makes crop production development significantly linked to the class of used fertilizers to give critical nutrients to plants. The nature and characteristics of released nutrients vary according to chemical, organic, and biofertilizers. Each form of fertilizer has benefits and drawbacks regarding crop growth and soil fertility (Chen, 2006). Furthermore, the texture of most sandy soils makes a high propensity towards nutrient loss leading to lower nutrient levels. Luckily, fertility management of such soils using organic resources in the tropics efficiently provides nutrients in the short term and contributes to soil organic matter (SOM) formation in the long term (Bationo *et al.,* 2007).

Two major obstacles could limit the usage of organic fertilizers, including green manure, farmyard manure, crop residues, and composts, regarding their quantity and/or quality. Regarding quantity, stakeholders usually suffer the quantity as a problem because organic fertilizers are traditionally unsatisfactory for needs. Meanwhile, the quality of organic fertilizers is associated with how the nutrient release patterns can be synchronized with crop uptake in sufficient amounts, which proceed at a slow rate and quantitively impoverished nutrients (Kimani and Lekasi, 2004). There is a campaign for the application of compost as organic fertilizer worldwide due to its preferable advantages over agrochemical fertilizers (Koning and Smaling, 2005). It is known that mineral fertilizers instantly release their ingredients in the soil as soon as it has been added in contrast to compost which gradually liberates its nutrients after it firstly has been decomposed (Tejada and Gonzalez, 2007) by the action of soil biota before they eventually die and mineralizes nutrients. The rate of mineralization of compost could be affected by factors such as climate, soil moisture, soil type, the composition, formulation, and characteristics of the raw materials, maturity of the compost, and composting technology (Diacono and Montemurro, 2010).

The decomposition of lignocelluloses contained in organic fertilizers is a complex process that inevitably comprises many microorganisms, but the attention is commonly focused on fungi as efficient decomposers because the lignocelluloses are refractory to decompose and extraordinary require an appropriate inoculum. Filamentous fungi are essential in recycling nutrients in an ecosystem by producing a wide variety of enzymes having various catalytic activities to hydrolysis lignocellulose-containing materials such as plant cell walls (Andlar *et al.,* 2018). White-rot fungi have a unique and competent ability to decompose all lignocellulose constituents to complete mineralization to CO_2 especially lignin as compared with brown-rot and soft-rot fungi (Couturier and Berrin, 2013). Ascomycetes such as *Trichoderma sp.* and white-rot fungi basidiomycetes such as *Phanerochaete sp.* as well could be an interesting resource of lignocellulose-active enzymes cocktail capable of causing decomposition of lignocelluloses (Sanchez, 2009). From another point of view, *Trichoderma sp.* represents a genus of the Hypocreaceae family that commonly inhabits the rhizosphere as plant growth-promoting fungi (PGPF) by generating a favourable environment and producing secondary metabolites to stimulate plant growth (Zin and Badaluddin, 2020), making the application of it should be promoted for sustainable agriculture by reducing the use of harmful chemicals in the agriculture field (Thapa *et al.,* 2020). Also, *P. chrysosporium* has recently been applied to alleviate salt stress and markedly increase growth parameters (Dief *et al.,* 2021).

Considering the aforementioned review, the current issue focuses on the hypothesis that augmentation of organic fertilizers with lignocellulose decomposers potentially enhances the growth and productivity of wheat plants cultivated in sandy soils by reducing amounts of synthetic fertilizers by dint of enhancing mineralized nutrients as well as plant growth factors.

MATERIALS AND METHODS

Fungal inoculum:

A consortium of two cellulolytic viz *Trichoderma harzianum* and *Trichoderma viride* and one ligninolytic viz *Phanerochaete chrysosporium* were nominated as fungal inoculum for compost decay. The stated fungi were provided by Biofertilizers Unit, Soil, Water and Environment Research Institute (SWER), Agricultural Research Center (ARC), Egypt. The fungi were preserved on Potato Dextrose Agar slants (Atlas, 2005). The fungi inoculum was prepared separately by inoculating a loopful of each fungus into a boiled and sterilized broth of 2% barley grains (Etter, 2018) and incubated at 30°C for ten days under ambient surroundings. The full production of each strain encompassing mycelium, spores, and grains was included as the inoculum. The inoculum was counted for the concentration of spores using a hemacytometer (4.1 x 10^9 spores/ml) and estimated for cell viability by calculating the colony forming unit (5.7 x 10^8 CFU/ml). After that, all three cultures were homogenously mixed in a blender before their application to degrade compost.

Compost processing:

A ready-prepared compost was applied to represent an organic fertilizer that was kindly provided by SWERI, ARC, Egypt. The compost was sampled for physiochemical and maturity analysis as described in Trautmann and Krasny (1997). According to data in **Table (1)**, the used compost is biologically moderate stable and mature.

Table 1. The main traits of used compost

Property	Unit	Value
Bulk density	kg/m^3	562
Moisture content	%	35.71
Water holding capacity	%	196.54
pH (1:10 extract)	-	6.86
Electrical conductivity (EC)	dS m^{-1}, at 25ºC	3.12
Organic matter	%	43.97
Total-N	%	1.27
C/N ratio	-	19.26
Total-P	%	0.85
Total-K	%	1.87
Total soluble-N	mg/kg	814.12
Available P	mg/kg	261.76
Available K	mg/kg	895.23
Respiration Rate	mg CO_2•C/ g organic carbon/day	7.83
Cress Germination Index	-	0.85

Before sowing, one-half amount of the applied compost that was going to be processed was moistened to about 55% of WHC with tap water, mixed with fungal inoculant at a rate of one liter per ton, manually turned, heaped, and covered with a plastic sheet for 24 h. The second half amount was left without any processing.

Field experiment and sampling:

A field trial was performed in sandy soil at Ismailia Agricultural Research Station, Ismailia Governorate, located by coordinates Latitude 30° 35′ 41. 901″ N and Longitude 32° 16′ 45. 843″ E, Egypt, throughout two growing winter seasons of 2019/2020 and 2020/2021 on 20th and 18th of November, respectively. The soil was sampled at 0 –20 cm depth, air-dried, ground and sieved to 2 mm for physical and chemical analysis according to the methods documented by Alef and Nannipieri (1995). The obtained values are presented in **Table (2)**.

Wheat (*Triticum aestivum* cv. Misr 3) was generously supplied by Wheat Research Department, Field Crops Research Institute (FCRI), ARC, Giza, Egypt. Factorial experiment was planned with two factors and four blocks in a split-plot design. The first factor included three rates of NPK fertilizers were assigned into main plots (plot area, 10.5 m^2), while the second factor represented the fungal processed or unprocessed compost assigned into subplots as the following: T1) 100% NPK + un-inoculated compost; T2)100% NPK + inoculated compost; T3) 75% NPK + un-inoculated compost; T4) 75% NPK + inoculated compost; T5) 50% NPK + un-inoculated compost; or T6) 50% NPK + inoculated compost.

Table 2. Physical and chemical analysis of the soil

Property	Unit	Season 2019/2020	Season 2020/2021
Particle size distribution:	-		
Sand	%	90.21	88.92
Silt	%	4.49	4.78
Clay	%	5.29	6.30
Texture grade	-	Sandy	Sandy
Saturation percent (S.P)	%	19.84	21.24
pH (1:2.5 water extract)	-	7.31	7.53
Electrical conductivity (EC)	dS m^{-1}, at 25°C	0.32	0.37
Organic matter	%	0.31	0.34
Total soluble- N	mg/kg	19.72	20.13
Available- P	mg/kg	5.32	5.17
Available-K	mg/kg	44.62	47.92

All agronomical practices were managed as instructed by the Egyptian Ministry of Agriculture and Land Reclamation recommendations for wheat cultivation on newly reclaimed soils, except for stated treatments. Each mineral fertilizer was added at rates of 50, 75, or 100% of the total recommended dose. Phosphorus was added during soil preparation as calcium superphosphate (15.5 % P_2O_5) at 240, 360 or 480 kg/hectare rates, respectively. Nitrogen fertilizer was added at 144, 216, or 288 kg N/hectare rates, respectively, as ammonium sulfate (20.5% N) was divided into four equal doses at 10, 20, 30, and 40 DAS. The potassium was added as potassium sulfate (48% K_2O) at 120, 180, or 240 kg/hectare rates, respectively, at 15 and 30 DAS, equally split into two doses. The processed and unprocessed compost were applied at 24 tons/hectare 10 days before sowing.

For sampling, the whole plants including roots with surrounding rhizosphere were randomly uprooted using a D-Handle digging shovel at 80 DAS from each plot and gently detached roots from shoots. The rhizosphere was characterized in terms of microbiome count and biological activity. Some vegetative parameters of shoots, include plant height (cm), the number of tillers per plant, shoot dry weight (gm/plant), leaf area (cm^2), and dark green colour index. Furthermore, the roots were dried to quantify root dry weight (gm/plant), root surface area and Shoor/Root Ratio. Before harvesting, plants were randomly sampled using a wooden frame (0.5 x 0.5m) to count the number of spikes per square meter and the number of kernels per spike. Plants of all plot areas (10.5 m^2) were harvested for calculating biological yield (ton ha^{-1}), straw yield (ton ha^{-1}), grain yield (ton ha^{-1}), and harvest index. The grains were characterized by the weight of 1000-grains and crude protein percentage.

Characterization of the rhizosphere microbiome:

An estimation of culturable heterotrophic bacteria and saprophytic fungi as well as many functional groups that occasionally participate in the biogeochemical cycling of carbon (cellulose, starch, and protein decomposers), nitrogen (free-living nitrogen-fixers), and phosphorus (phosphate dissolvers). Aliquots of five grams of rhizosphere were homogenized in 95 mL of a sterile saline solution of 0.85% NaCl, and maintained at 5°C. Ten-fold dilutions were pipetted (100 µL) and spread on the plates containing specific culture media as described by Alef and Nannipieri (1995), phosphate dissolvers were cultured on modified Bunt and Rovira's agar medium according to Louw and Webley (1958). Plates were incubated at 28°C and monitored for 3-10 days to develop a colony-forming unit (CFU) on agar plates. The number of each group was computed based on the dry weight of the soil. The plates were flooded with 0.1% Congo solution, iodine solution, or 0.1 N HC1 solution to observe halos around colonies to detect cellulolytic, amylolytic and proteolytic activities of the colonies, respectively, while a direct observation of halo zones or grown colonies was used for phosphate dissolvers or nitrogen fixers detection, respectively.

Microbial activity assay:

The soil respiration rate was calculated from the amount of CO_2 evolved and trapped in a NaOH solution during the incubation of 20 g soil in a closed jar at 28°C for 24 h. Dehydrogenase enzyme was quantified based on red colour intensity by reduction of 2,3,5-triphenyl tetrazolium chloride (TTC) to Triphenyltetrazolium formazan (TPF) in 5 g soils after incubation at 28°C for 24 h. Nitrogenase activity was estimated based on the amount of ethylene formed during the incubation of 10g soil with acetylene in previously incubated air-tight jars at temperatures of 28°C for 48h (Alef and Nannipieri, 1995). Alkaline phosphatase was assayed calorimetrically using *p*-nitrophenyl phosphate disodium hexahydrate (PNP) as a chromogenic substrate according to the procedures of Tabatabai and Bremner (1969).

The morphology of the above-ground part of plants was assayed in terms of shoot height, tillers No., and shoot dry weight. Meanwhile, the below-ground part was evaluated regarding root dry wt., root surface area, and root/shoot ratio. For each treatment, the complete terminal leaf of five plants was detached and captured with 300 dots per inch (dpi) resolution using a flatbed scanner (HP Scanjet G2710). The captured images were used to measure leaf area (LA), according to *Baker et al.* (1996). A measured LA and dry weight of the leaf was used to calculate the specific leaf area (SLA) and specific leaf weight (SLW), according to Amanullah (2015). The images also were processed to extract values of RGB using Adobe Photoshop CS6 Ver. 13-Extended. The dark green colour index (DGCI) was calculated from hue, saturation, and brightness (HSB) levels as described by Karcher and Richardson (2003). Root surface area was estimated using 0.1N NaOH for measuring the absorbed amount of 1N HCl on roots (Carley and Watson, 1966). Biological yield (ton ha^{-1}) was calculated from whole plants of each plot. The harvest index was presented as a grain percentage from the total biological yield. Concentrations of nitrogen, phosphorus and potassium were quantified in wet digests of wheat grains using the micro-Kjeldahl method, spectrophotometrically using ammonium molybdate with stannous chloride reagents and a flame photometer, respectively (Page *et al.,* 1982). Nutrient uptake (kg ha^{-1}) was calculated by multiplying the grain yield (kg ha^{-1}) by the nutrient concentration. Crude protein percentage in grains by multiplying the nitrogen percentage by 5.7 factor, according to Mariotti et al. (2008).

Statistical analysis:

The resulting data were statistically analyzed for an analysis of variance (ANOVA) as well as estimation of main effects and interactions according to computations of Petersen (1994) using CoState statistical software version 6.4 (CoHort Software,. Monterey, CA, USA). Fisher's least significant difference (LSD) test was used to compare treatment means at a 5% level probability.

RESULTS

Rhizosphere microbiome biodiversity:

Broadly, soil microbiomes have a pivotal role in agroecosystem function and sustainability due to their influential contribution to nutrient cycling and maintaining soil structure (Prasad *et al.,* 2021). Concretely, the rhizosphere or root microbiome is recruited from a larger diverse range of microbes than that present in the surrounding bulk soil (Kour *et al.,* 2019). So, harnessing the beneficial potential of the rhizobiome can provide a sustainable option for raising agricultural crop production. Accordingly, the influence of processed compost and mineral fertilizers rates on biodiversity of rhizobiome based on biogeochemical cycles, as a critical ecosystem function for plant nutrition (Saleem *et al.,* 2019), is portrayed by **Fig. (1)** in terms of heterotrophic bacteria, saprophytic fungi, cellulolytics, amylolytics, proteolytics, N-fixers, and phosphate dissolvers. The obtained data showed a fluctuation in the microbial count for different microbial groups to dominate heterotrophic bacteria (ranged from 13.3 to 87 X 10^6 and 16 to 89 X 10^6 cfu/ g dry soil during the first and second seasons, respectively), followed by proteolytic (ranged from 9 to 11 X 10^4 and 9 to 16 X 10^4 cfu/ g dry soil during the first and second season, respectively) and saprophytic fungi (ranged from 5 to 10.2 X 10^4 and 5.6 to 10.5 X 10^4 cfu/ g dry soil during the first and second season, respectively) and lowest domination of phosphate dissolvers. Furthermore, the organic matter generally stimulated the proliferation of all microbial groups, which was maximized by the lignocellulolytic enriched compost, especially when combined with 75% NPK fertilization. Meanwhile, a reduction in NPK fertilization to 50% sharply declined overall microbial count followed by full dose fertilization of mineral fertilizers with little influence on saprophytic fungi compared to other groups.

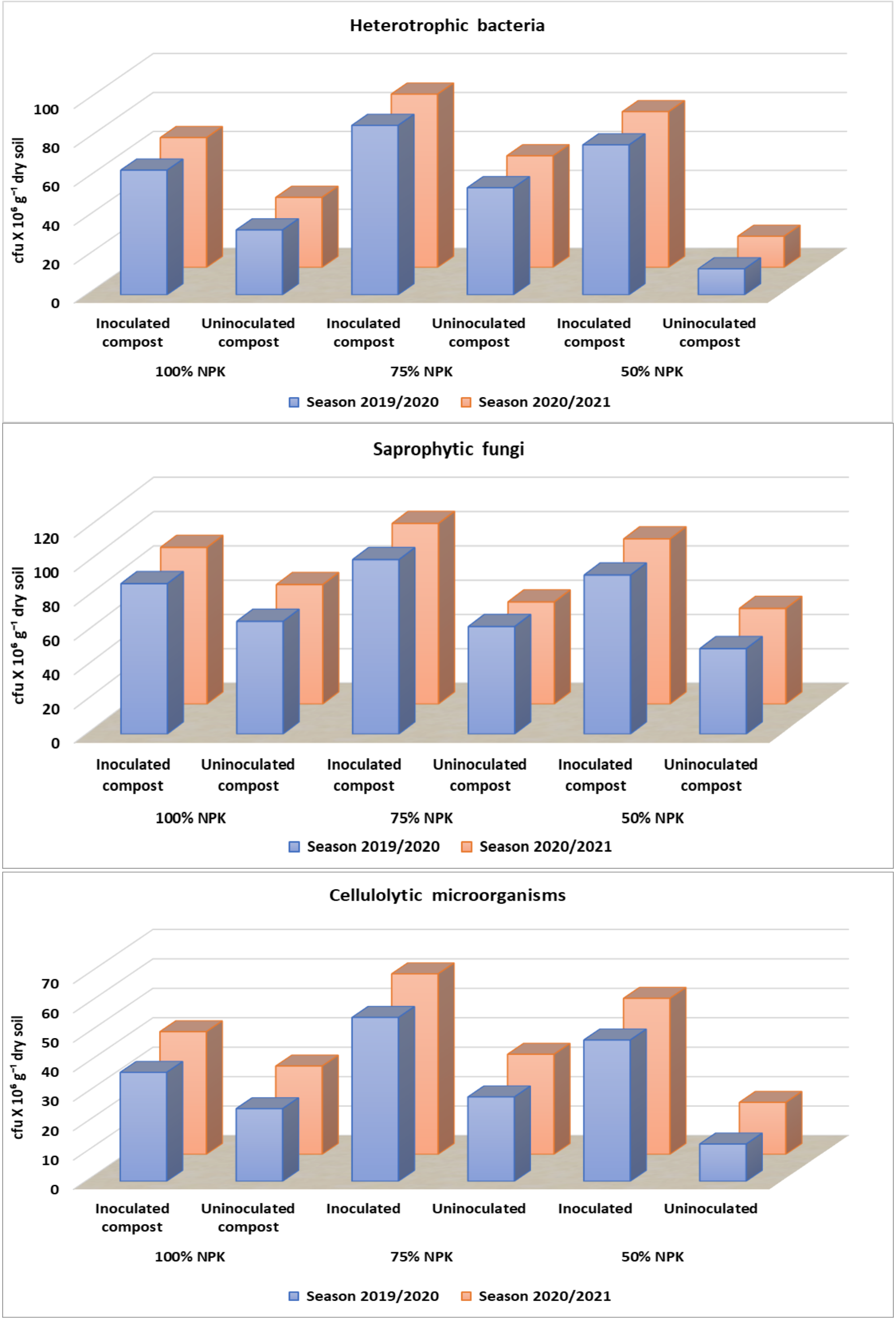
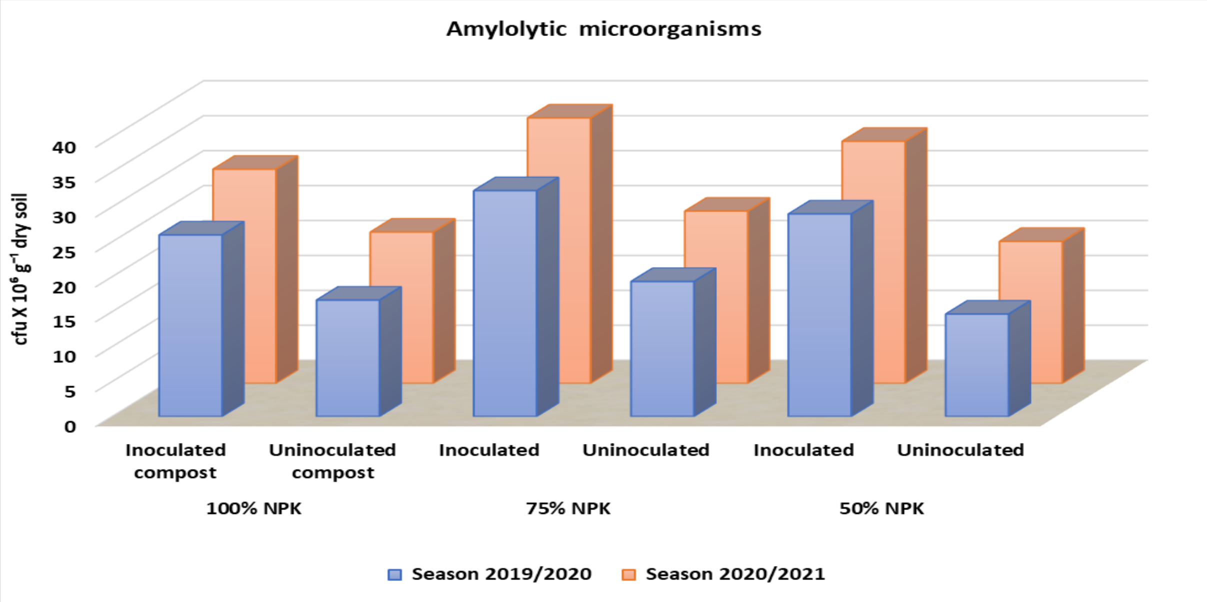
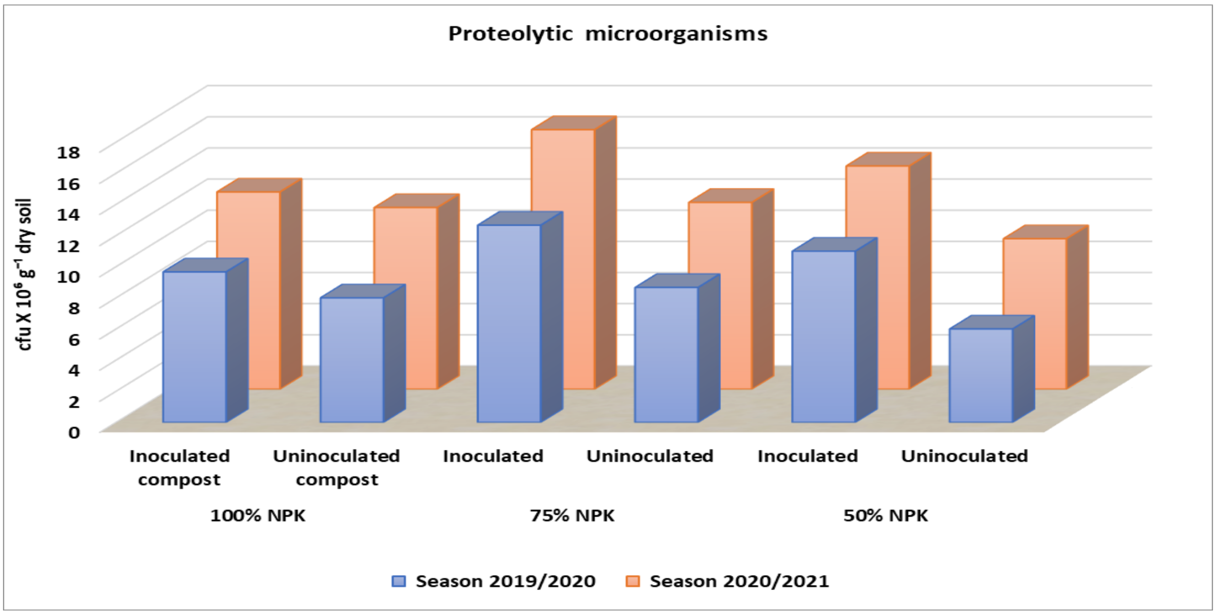
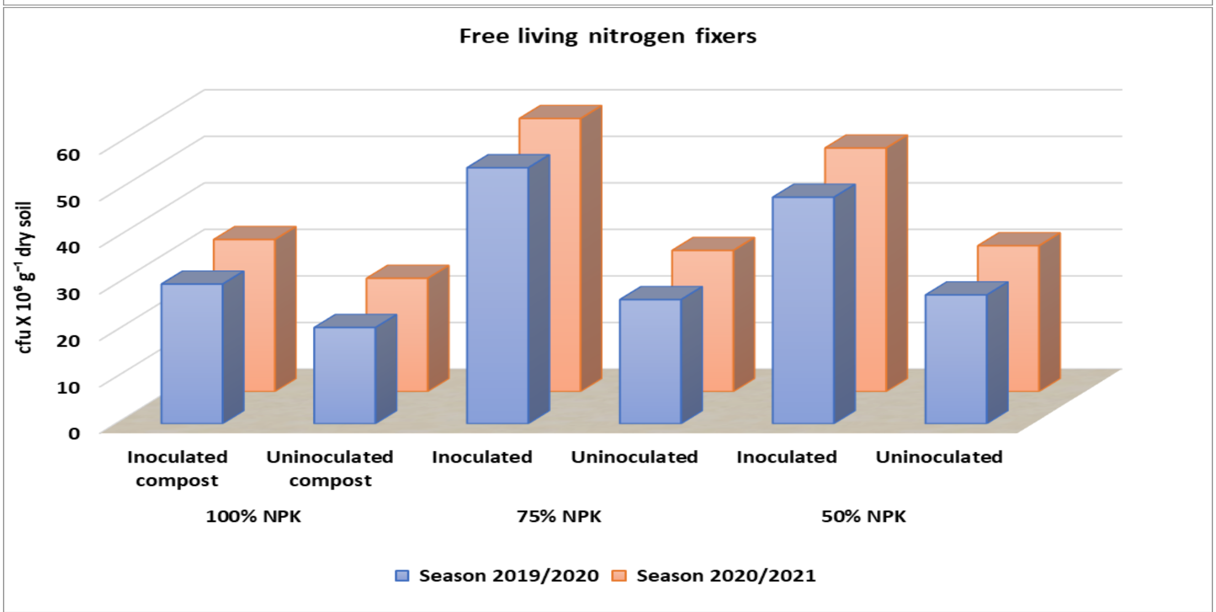


Fig. 1. Effect of lignocellulosic decomposers augmentation on rhizosphere microbial community of wheat plants


Amylolytic microorganisms
cfu X 10^6 g^-1 dry soil
40
35
30
25
20
15
10
5
0
Inoculated compost
Uninoculated compost
Inoculated
Uninoculated
Inoculated
Uninoculated
100% NPK
75% NPK
50% NPK
Season 2019/2020
Season 2020/2021


Proteolytic microorganisms
cfu X 10^6 g^-1 dry soil
18
16
14
12
10
8
6
4
2
0
Inoculated compost
Uninoculated compost
Inoculated
Uninoculated
Inoculated
Uninoculated
100% NPK
75% NPK
50% NPK
Season 2019/2020
Season 2020/2021


Free living nitrogen fixers
cfu X 10^6 g^-1 dry soil
60
50
40
30
20
10
0
Inoculated compost
Uninoculated compost
Inoculated
Uninoculated
Inoculated
Uninoculated
100% NPK
75% NPK
50% NPK
Season 2019/2020
Season 2020/2021

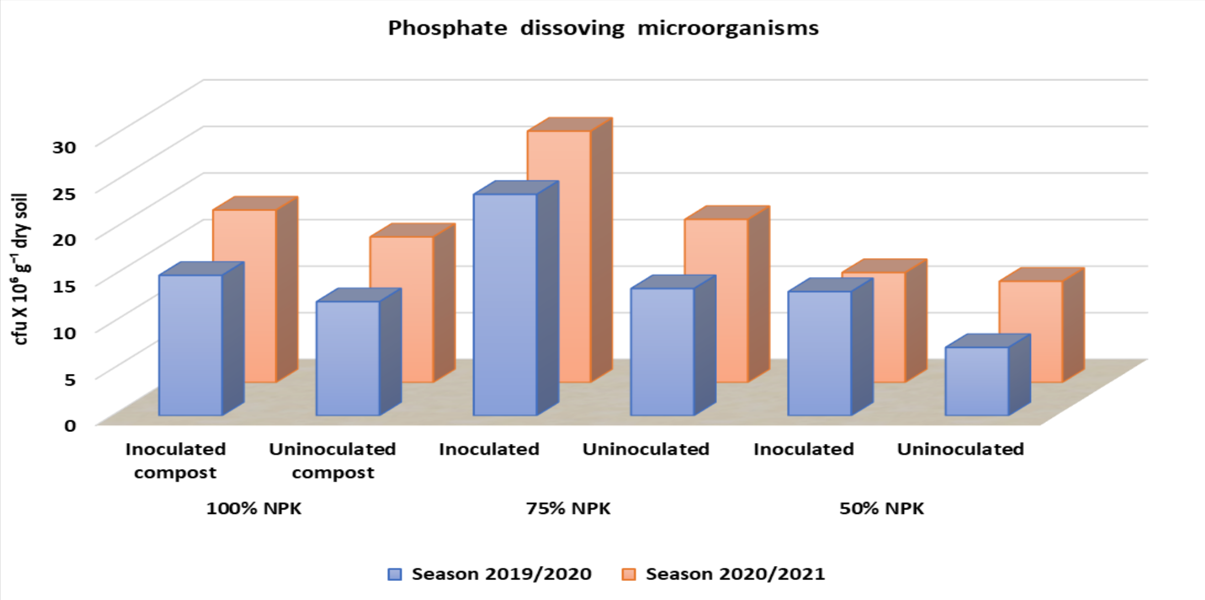


Fig. 2. Effect of lignocellulosic decomposers augmentation on rhizosphere microbial community of wheat plants

Biological activity in the rhizosphere:

From the microbiological point of view, the root area is characterized by a powerful dynamic by functional groups of microorganisms with high specificity towards the available substrate and enzymatically capable of converting it to accessible forms to plants (Canbolat *et al.,* 2006). The biological activity of wheat rhizosphere colonized with lignocellulolytic fungi and received the different rates of NPK mineral fertilizers was estimated in terms of soil respiration rate, dehydrogenase enzymes, nitrogenase, and alkaline phosphatase as an indication of an ecosystem functioning, and the data are tabulated in **Table (3)**. The application of inoculated compost significantly stimulated biological activity during two seasons compared to unprocessed one.

Table 2. Effect of lignocellulolytic fungi augmentation on the biological activity of wheat rhizosphere

Parameters / Treatments		Soil respiration (mg CO_2•C g^{-1} organic carbon day^{-1})		Dehydrogenase activity* (µg TPF g^{-1} DW soil day^{-1})		Nitrogenase activity (mmol C_2H_4 g^{-1} DW $soil^{-1}$ day^{-1})		Alkaline Phosphatase** (mg PNP g^{-1} DW soil hr^{-1})	
		Season 2019/20	Season 2020/21	Season 2019/20	Season 2020/21	Season 2019/20	Season 2020/21	Season 2019/20	Season 2020/21
The main effect of inoculation									
Un-inoculated compost		8.86	10.53	198.13	216.53	15.19	18.86	11.59	15.19
Inoculated compost		14.80	16.33	252.75	271.19	18.68	22.25	18.84	22.40
LSD0.05		2.46	4.17	20.67	23.79	3.65	3.21	4.33	5.16
The main effect of mineral fertilizers rate									
100% NPK		10.63	12.37	200.05	218.39	10.64	14.26	15.42	19.22
75% NPK		14.15	15.87	239.73	257.98	21.94	25.69	17.51	20.76
50% NPK		10.72	12.04	236.55	255.22	18.22	21.72	12.71	16.40
LSD0.05		2.18	3.17	23.89	25.45	3.52	3.67	2.75	1.32
Interaction effect									
100% NPK	**Un-inoculated compost**	9.23	11.01	197.94	216.27	10.23	13.43	11.87	15.82
	Inoculated compost	12.04	13.74	202.15	220.50	11.04	15.09	18.98	22.63
75% NPK	**Un-inoculated compost**	11.13	13.10	210.23	228.63	20.12	23.98	13.78	17.05
	Inoculated compost	17.16	18.64	269.23	287.33	23.76	27.40	21.23	24.47
50% NPK	**Un-inoculated compost**	6.23	7.47	186.23	204.69	15.21	19.18	9.12	12.71
	Inoculated compost	15.21	16.62	286.87	305.75	21.23	24.25	16.30	20.09
LSD0.05		2.26	1.97	35.80	41.20	ns	ns	6.94	7.15

*TPF= Triphenyltetrazolium formazan.** PNP= p-nitrophenyl phosphate disodium hexahydrate.

The processed compost addition recorded 67.04 and 55.08; 27.57 and 25.24; 22.98 and 17.97 or 62.55 and 47.47% increases over unprocessed one for soil respiration, dehydrogenase enzymes, nitrogenase, or alkaline phosphatase during the first and second seasons, respectively. Mineral fertilization, in their main effect, also revealed significant differences based on the added rate with a superiority of 75% NPK to surpass the full or half doses for all estimated activities. Although significant differences are due to process compost with lignocellulolytic fungi, or NPK rates, the compost differences depend on NPK rate, except for nitrogenase activity during two seasons. The maximum activities were achieved in rhizospheres that received 75% NPK combined with processed compost, as indicated by soil respiration and alkaline phosphatase. While overall microbial activity was maximized by 50% NPK combined with processed compost, as indicated by dehydrogenase values. The heavy dose of NPK fertilizers hindered the biological activity in wheat rhizospheres.

Morphology of above-ground part of wheat:

The above-ground part of wheat plants that received fungal inoculant, through processed compost, with rates of NPK fertilizer was wholly appraised for shoot viz., plant height, number of tillers and shoot dry weight, **Table (4)**, as well as specifically for leaf traits viz., LA, SLA, SLW and DGCI, **Table (5)**. Data pertaining to the plant height revealed that each level of NPK significantly differs from the other. The tallest plants (86.37 and 87.31cm during the 1st and 2nd seasons, respectively) were attained, where the full dose of NPK was applied against 50% of NPK fertilizer that stunted the plants. Meanwhile, an inoculated compost recorded taller plants against uninoculated ones; a significant difference appeared in the 2nd season. The non-significant difference as a result of processed compost was recorded against rates of NPK fertilizers which significantly impact the number of tillers per plant to be maximized with the full dose of NPK fertilizer. The dry shoot weights generally increased in order 100%NPK > 75%NPK > 50%NPK with a non-significant difference between 100% and 75% treatments. In the meantime, heavier shoots were significantly yielded where the inoculation of compost with lignocellulolytic fungi was applied during both seasons with a non-significant difference in combination with 100% or 75% from the full dose against the lightest shoots as a result of a 50% reduction in the amount of NPK fertilizer.

Table 3. Effect of lignocellulolytic fungi augmentation on some shoot components of wheat plants

Parameters / Treatments		Plant height (cm)		Number of tillers plant^{-1}		Shoot dry weight (g plant^{-1})	
		Season 2019/20	Season 2020/21	Season 2019/20	Season 2020/21	Season 2019/20	Season 2020/21
The main effect of inoculation							
Un-inoculated compost		80.96	78.11	3.68	4.43	2.70	3.49
Inoculated compost		83.51	83.79	4.26	4.66	3.69	4.31
LSD0.05		ns	5.25	ns	ns	0.45	0.32
The main effect of mineral fertilizers rate							
100% NPK		86.37	87.31	5.18	5.71	3.85	4.69
75% NPK		82.79	81.50	3.95	4.60	3.48	4.42
50% NPK		77.55	74.05	2.79	3.33	2.26	2.61
LSD0.05		2.41	6.29	0.94	0.72	0.44	0.52
Interaction effect							
100% NPK	**Un-inoculated compost**	85.20	85.12	4.76	5.54	3.17	3.95
	Inoculated compost	87.54	89.50	5.60	5.89	4.53	5.42
75% NPK	**Un-inoculated compost**	81.18	77.34	3.53	4.48	2.78	3.71
	Inoculated compost	84.40	85.65	4.37	4.71	4.18	5.12
50% NPK	**Un-inoculated compost**	76.50	71.87	2.76	3.27	2.15	2.82
	Inoculated compost	78.60	76.23	2.82	3.39	2.36	2.40
LSD0.05		ns	ns	ns	ns	0.77	0.55

Table 4. Effect of lignocellulolytic fungi augmentation on some leaf traits of wheat plants

Parameters / Treatments		LA* (cm^2)		SLA (cm^2/g dry leaf)		SLW (mg/cm^2)		DGCI	
		Season 2019/20	Season 2020/21	Season 2019/20	Season 2020/21	Season 2019/20	Season 2020/21	Season 2019/20	Season 2020/21
The main effect of inoculation									
Un-inoculated compost		26.87	29.25	58.30	58.12	17.27	17.33	0.39	0.44
Inoculated compost		38.85	41.18	52.61	51.89	19.08	19.36	0.55	0.62
LSD0.05		2.44	1.24	3.85	3.75	1.27	1.12	0.023	0.022
The main effect of mineral fertilizers rate									
100% NPK		39.46	41.80	51.75	52.45	19.37	19.20	0.60	0.63
75% NPK		32.25	34.61	56.24	54.81	17.89	18.34	0.44	0.54
50% NPK		26.89	29.23	58.37	57.76	17.26	17.49	0.36	0.43
LSD0.05		1.81	1.76	2.03	2.92	0.62	0.81	0.035	0.052
Interaction effect									
100% NPK	**Un-inoculated compost**	36.64	39.01	53.34	56.04	18.78	17.92	0.55	0.56
	Inoculated compost	42.27	44.60	50.17	48.85	19.97	20.48	0.65	0.70
75% NPK	**Un-inoculated compost**	24.54	26.92	59.31	58.09	16.93	17.23	0.37	0.47
	Inoculated compost	39.95	42.30	53.17	51.53	18.86	19.45	0.51	0.60
50% NPK	**Un-inoculated compost**	19.43	21.81	62.25	60.21	16.11	16.84	0.24	0.30
	Inoculated compost	34.34	36.65	54.49	55.30	18.42	18.14	0.48	0.56
LSD0.05		4.23	2.14	ns	ns	ns	ns	0.039	0.037

*LA= Leaf Area; SLA= Specific Leaf Area; SLW= Specific Leaf Weight; DGCI= Dark Green Color Index.

The average increases caused by processed compost ranged from 23.50 to 36.67% over non-inoculated treatments during both seasons. More availability of organic nutrient compounds by the action of hydrolytic enzymes excreted from saprobe fungi may infer why inoculated fungi may sustain the benefits of compost for plant growth. Such action was submitted to the highest biodiversity and/or activity of wheat rhizobiome with the combination of processed compost and 75% of NPK fertilizers **(Figure 1 and Table 3)** to exert plant growth-promoting microorganisms.

The leaf is the chief partner in the photosynthesis process for producing more than 90% of organic matter in the plant and mediates resources and energy fluxes in the ecosphere (Hou *et al.,* 2020). Furthermore, the nutrition needs of winter wheat make leaf characteristics have a great influence on the crop yield during grain formation and plumping because supplementing photosynthesis products which relatively require large amounts of mineral elements for vegetative development and positively respond to the application of mineral fertilizers (Bojović and Stojanović, 2006). Dependent on processed compost during both seasons, the rates of NPK fertilizers significantly affected the leaf area of wheat plants. The maximum breadth leaves were observed on wheat plants treated with inoculated compost combined with 100% or 57% NPK fertilizers with non-significant differences. Meanwhile, the un-processed compost widely narrowed the leaves especially when with a 50% reduction in mineral fertilizers. On the other hand, the lower values of SLA and higher values of SLW independently detected more thickness leaves with the processed compost or high rates of mineral fertilizers (100% or 75% of full dose) against unprocessed compost or lowest rate of mineral fertilizers. A visual examination of leaf greenness using DGCI recorded darker green colors of leaves with increasing NPK rates especially when combined with inoculated compost over uninoculated one.

Morphology of underground part of wheat:

An essential feature of the below-ground part of a cultivated crop is its root foraging performance as a duct for soil mineral and water procurement, which is innately correlated to root system architecture. Root architecture and morphology are aspects used to express the properties of root systems which play a vital role in the improvement of plant development and crop yield. Under the current study, wheat roots are represented in terms of dry weight per plant, surface area, and the ratio to above-ground shoot, as tabulated in **Table (6)**.

Table 5. Effect of lignocellulolytic fungi augmentation on some root traits of wheat plants

Parameters / Treatments		Root dry wt. ($g\ plant^{-1}$) Season 2019/20	Root dry wt. Season 2020/21	Root surface area ($ml\ NaOH\ plant^{-1}$) Season 2019/20	Root surface area Season 2020/21	Root/Shoot Ratio Season 2019/20	Root/Shoot Ratio Season 2020/21
Main effect of inoculation							
Un-inoculated compost		1.30	1.56	18.26	20.37	0.50	0.46
Inoculated compost		1.26	1.38	22.94	31.36	0.35	0.34
LSD0.05		ns	0.10	1.91	2.09	0.03	0.03
Main effect of mineral fertilizers rate							
100% NPK		1.29	1.51	23.26	28.26	0.34	0.33
75% NPK		1.41	1.59	22.76	27.36	0.43	0.37
50% NPK		1.14	1.31	15.78	21.98	0.51	0.50
LSD0.05		ns	ns	1.31	2.69	0.11	0.09
Interaction effect							
100% NPK	**Un-inoculated compost**	1.18	1.44	22.27	22.91	0.37	0.37
	Inoculated compost	1.39	1.58	24.26	33.61	0.31	0.29
75% NPK	**Un-inoculated compost**	1.41	1.60	18.35	19.20	0.51	0.43
	Inoculated compost	1.41	1.58	27.17	35.52	0.34	0.31
50% NPK	**Un-inoculated compost**	1.32	1.64	14.16	19.00	0.61	0.58
	Inoculated compost	0.97	0.97	17.39	24.96	0.41	0.41
LSD0.05		0.22	0.17	3.32	3.62	0.05	0.05

During both seasons, the morphological traits of wheat roots reacted differently with processed compost according to the rate of NPK applied for each measured trait. Although the processed compost decreased the dry weight of roots, it produced more fine extended roots, over unprocessed compost, and more dry mass of associated shoots, as indicated by values of surface area and root/shoot ratio, respectively. Depending on the NPK rate, the processed compost generated the finest roots with a 75% NPK rate followed by full-dose treatment. In contrast, the combined application of processed compost with the full dose of NPK recorded the minimum value of root/shoot ratio, which could be attributed to high shoot mass.

Nutrients uptake:

The nutrient uptake into wheat seeds in response to organic matter inoculated with lignocellulolytic fungi and combined with the gradient rate of NPK fertilizers estimated in terms of N, P, or K kg uptake per hectare is tabulated in **Table (7)**. The inoculated compost significantly enhanced the uptake of N, P, and K nutrients into wheat seeds as compared to uninoculated compost in both seasons. Also, rising in the rate of NPK fertilizers had been accompanied by a significant increase in nutrient uptake. However, the enhancement due to processing compost was significantly dependent on the rate of NPK fertilizers.

The maximum uptake of N, P, or K nutrients was achieved when the inoculated compost was combined with 100% or 75% of full-dose NPK fertilizers, with a non-significant difference, during both seasons.

Wheat yield components:

Rational cultivation management positively has an imperative action on wheat yield by improving the contributions of yield components. Some of the yield components of wheat were evaluated based on straw yield, number of spikes per unit area, number of kernels per spike and biological yield resulting from cultivation on a sand soil with saprobic fungi-augmented organic matter and rates of NPK mineral fertilizers. The obtained data are represented in **Table (8)**. For straw yield, the number of kernels per spike along with biological yield revealed a significant increment due to the application of fungal processed compost by 14.89 and 11.33%, 14.67 and 3.69% along with 15.10 and 13.12% for such parameters during 1st and 2nd seasons, respectively.

An increasing rate of mineral fertilizers up to full dose significantly boosted all assayed components of yield by 54.38 and 64.11%, 26.96% and 22.78, 43.09% and 44.55%, as well as 39.87 and 46.16% over half dose for Straw yield, number of spikes, number of kernels per spike as well as biological yield during 1st and 2nd seasons, respectively. The corresponding increments over 75% of the full dose were 28.17 and 28.64%, 7.45 and 6.71%, 13.81 and 14.96%, as well as 18.93 and 19.9 %, respectively. Whereas the interaction effect has no significance for the number of spikes or number of kernels/spikes, it significantly revealed variation in other components.

Table 6. Effect of lignocellulolytic fungi augmentation on nutrient uptake by wheat plants

Parameters		Nitrogen Uptake (kg ha^{-1})		Phosphorus Uptake (kg ha^{-1})		Potassium Uptake (kg ha^{-1})	
Treatments		Season 2019/20	Season 2020/21	Season 2019/20	Season 2020/21	Season 2019/20	Season 2020/21
The main effect of inoculation							
Un-inoculated compost		68.22	69.25	9.82	10.22	20.87	20.61
Inoculated compost		84.85	88.39	12.57	12.94	27.25	29.18
LSD0.05		4.9	6.64	0.63	0.21	1.77	0.64
The main effect of mineral fertilizers rate							
100% NPK		93.26	97.35	15.15	14.10	29.53	30.62
75% NPK		77.38	77.36	11.00	11.41	24.04	24.83
50% NPK		58.97	61.76	7.44	9.25	18.61	19.24
LSD0.05		5.19	14.54	1.64	0.39	3.96	3.98
Interaction effect							
100% NPK	**Un-inoculated compost**	88.81	93.36	14.27	13.15	27.63	27.94
	Inoculated compost	97.71	101.33	16.03	15.04	31.42	33.30
75% NPK	**Un-inoculated compost**	66.75	64.22	8.65	9.89	21.32	20.77
	Inoculated compost	88.01	90.50	13.34	12.92	26.75	28.89
50% NPK	**Un-inoculated compost**	49.10	50.18	6.53	7.63	13.65	13.13
	Inoculated compost	68.83	73.34	8.35	10.87	23.57	25.35
LSD0.05		8.49	11.51	1.10	0.36	3.07	1.12

Table 7. Effect of lignocellulolytic fungi augmentation on some yield components of wheat crop

Parameters		Straw yield (ton ha^{-1})		Number of spikes /m^2		Number of kernels /spike		Biological yield (ton ha^{-1})	
Treatments		Season 2019/20	Season 2020/21	Season 2019/20	Season 2020/21	Season 2019/20	Season 2020/21	Season 2019/20	Season 2020/21
The main effect of inoculation									
Un-inoculated compost		5.17	5.65	297.03	319.54	39.39	39.73	8.81	9.30
Inoculated compost		5.94	6.29	331.89	339.64	45.17	45.17	10.14	10.52
LSD0.05		0.22	0.62	ns	ns	4.27	5.12	0.33	0.62
The main effect of mineral fertilizers rate									
100% NPK		6.87	7.50	347.04	359.35	49.21	49.71	11.12	11.81
75% NPK		5.36	5.83	322.99	336.75	43.24	43.24	9.35	9.85
50% NPK		4.45	4.57	273.34	292.67	34.39	34.39	7.95	8.08
LSD0.05		0.75	0.82	38.22	43.67	5.05	3.54	0.51	1.16
Interaction effect									
100% NPK	**Un-inoculated compost**	6.73	7.65	332.23	346.73	47.59	48.59	10.85	11.81
	Inoculated compost	7.01	7.36	361.85	371.98	50.84	50.84	11.38	11.81
75% NPK	**Un-inoculated compost**	4.85	5.27	306.68	328.77	40.41	40.41	8.60	9.05
	Inoculated compost	5.86	6.39	339.31	344.72	46.07	46.07	10.10	10.64
50% NPK	**Un-inoculated compost**	3.94	4.02	252.19	283.12	30.18	30.18	6.97	7.05
	Inoculated compost	4.95	5.11	294.50	302.23	38.60	38.60	8.93	9.11
LSD0.05		038	1.19	ns	ns	ns	ns	0.56	1.08

Wheat grain yield:

Data in **Table (9)** indicate that differences between processed and unprocessed compost depended on the rate of NPK fertilizers; such differences and differences between NPK rates were highly significant for all evaluated grains' yield attributes except the percentage of harvest index. Despite the superiority of the full dose of NPK treatment, the divergence between them and 75% NPK fertilizers appeared non-significant when they were combined with processed compost. Meanwhile, a reduction by 50% of applied NPK significantly reduced most yield characters either when combined with processed or unprocessed compost. The average increases were 15.70 and 15.57%, 11.33 and 11.77% or 8.51 and 11.69% for grain yield, 1000-grains Wt. or grain protein during 1st and 2nd season, respectively, when applied compost was augmented with lignocellulosic fungi.

Table 8. Effect of lignocellulolytic fungi augmentation on some grain yield characters of wheat crop

Parameters / Treatments		Grain yield (ton ha^{-1})		Harvest index (%)		1000-grains Wt. (gm)		Grain protein (%)	
		Season 2019/ 20	Season 2020/ 21	Season 2019/ 20	Season 2020/ 21	Season 2019/ 20	Season 2020/ 21	Season 2019/ 20	Season 2020/ 21
The main effect of inoculation									
Un-inoculated compost		3.63	3.66	41.74	40.07	32.12	32.45	10.57	10.61
Inoculated compost		4.20	4.23	41.72	40.60	35.76	36.27	11.47	11.85
LSD0.05		0.20	0.21	ns	ns	1.72	1.42	0.41	0.41
The main effect of mineral fertilizers rate									
100% NPK		4.25	4.30	38.22	36.49	37.24	37.32	12.54	12.87
75% NPK		4.00	4.02	42.87	40.96	33.23	33.64	10.99	10.89
50% NPK		3.51	3.52	44.11	43.56	31.36	32.13	9.54	9.92
LSD0.05		0.43	0.41	ns	1.89	2.06	2.79	0.94	1.21
Interaction effect									
100% NPK	**Un-inoculated compost**	4.12	4.16	38.01	35.28	36.84	36.86	12.31	12.76
	Inoculated compost	4.37	4.45	38.43	37.70	37.64	37.79	12.76	12.99
75% NPK	**Un-inoculated compost**	3.75	3.78	43.68	41.84	30.57	30.68	10.15	9.67
	Inoculated compost	4.24	4.26	42.06	40.08	35.88	36.60	11.82	12.12
50% NPK	**Un-inoculated compost**	3.03	3.03	43.55	43.10	28.95	29.83	9.24	9.41
	Inoculated compost	3.98	4.00	44.68	44.02	33.76	34.43	9.84	10.44
LSD0.05		0.34	0.36	ns	ns	2.98	2.47	0.70	0.72

DISCUSSIONS

The results may indicate a successful incidence of inoculated fungi for decomposing organic matter and liberating various nutrients to be captured with other microorganisms. The recorded fluctuation may be due to the heterogenicity of organic matter for substrates resulting from dissimilar availability of consisting fractions for microorganisms nutrition (Janzen *et al.,* 1992). Along with a variation of the C/N ratio of various organisms, such as in the case of a higher C/N ratio of fungi (10) compared with bacteria (4) (Sterner and Elser, 2017) which makes fungi less sensitive to low nitrogen. Furthermore, the decomposition of organic matter by inoculated decomposers is inseparably linked with the synthesis of new organic compounds and the release of elements (mineralization) that discriminated the inoculated compost from the un-inoculated one and sequentially reflected on biodiversity in rhizobiome. In harmony with our results, Patrick and Adeniyi (2016) showed that soil treated with organic fertilizers enhanced total heterotrophic bacteria and phosphate solubilizers within the rhizosphere of maize plants compared to NPK fertilization due to the decomposition of organic matter, which is important for the proliferation of soil microorganisms in the soil. The stimulative impact of organic fertilizers against mineral fertilizers was lately reviewed by Dincă *et al.* (2022). Regarding the stimulative effect of the reduced amount of NPK, Cai *et al.* (2017) previously confirmed our results and concluded that the amalgamation of organic fertilizers and low mineral fertilizers could maintain microbiome diversity. They suggested that inoculated organic fertilizer with *Trichoderma* is a better option for maintaining a relatively sustainable microbiome in mono-cropped soils under a 25% reduction of inorganic fertilizer. Also, Tandon *et al.* (2018) attributed the inhibitory effect of 100%-NPK chemical fertilizers comparing 50%-NPK on bacterial CFU of microflora in chickpea rhizosphere to lowering soil pH and exert destructive effects caused by mineral fertilizers.

Unfortunately, little comparative work to correlate microbial diversity with associated enzymatic activities has been performed despite their theoretical and practical importance for many issues concerned with saving crop fertilization or bioremediation of organic pollutants (Egamberdieva *et al.*, 2011). However, based on a meta-analysis study of microbiome biodiversity and ecosystem functioning relationships by Saleem *et al.* (2019), microbial diversity may deliver numerous functions crucial to plant growth, including nutrient cycling, the defeat of pathogens, and/or production of phytohormones. Under the current study, microbiome biodiversity and ecosystem functioning relationships behaved a linear correlation by which ecosystem functioning increases with growing microbiome biodiversity as a result of niche differentiation. The previous findings by Caldwell (2005) demonstrated that microbial functional diversity is possibly indicated by soil enzyme activities, mainly rhizosphere enzymes.

Soil respiration is mainly originated from plant roots respiration and microbial decomposition of organic matter, which they termed autotrophic and heterotrophic respiration, respectively (Kim *et al.,* 2012). So, under the current study, the CO_2 efflux represents heterotrophic respiration of rhizosphere soil and intuitively does alike certain rhizobiome diversity. Meanwhile, dehydrogenase activity potentially provides an index of general oxidative activity of soil biota and the integrative biological activity of soils. Therefore, lower dehydrogenase activity indicates partial inhibition of many organisms' growth to hinder their contribution to the metabolic events of the soils and vis versa. The attained data corresponds with Laugale et al. (2020) for applying mineral fertilizers that cause a reduction in dehydrogenase activity compared to vermicompost applied to strawberries, pointing out a negative influence on soil fertility.

The limitation of nitrogenase activity due to chemical fertilizers and lower organic matter earlier consistently declared by Tang *et al.* (2021) but inconsistently found a dependent action of chemical fertilizers on the content of organic matter presumptively attributed it to more energy substrates provided by organic matter. Alkaline phosphatase, but not acid phosphatase, is mainly associated with microorganisms, so an increase in microbial biomass conferred the observed higher alkaline phosphatase activity. The enhanced decomposition of organic matter, especially with the action of inoculated fungi, appeared a regulatory influence on the alkaline phosphatase activity matching the findings of Tandon *et al.* (2018) for microbial activities in rhizosphere of chickpea inoculated with *Trichoderma koningiopsis* under dissimilar fertilization treatments.

Contextually, Arriagada *et al.* (2014) documented that saprobe fungi can produce hydrolytic enzymes to degrade organic matter into compounds accessible for plant uptake, including polysaccharides enzymes such as end endo-polymethyl galacturonase and endo-xyloglucanase. The given observations were validated by Mahato et al. (2018). When accompanied *Trichoderma* and NPK with farmyard manure, most of the growth parameters of wheat plants showed the highest value, but the yield was slightly higher than NPK alone treatment.

The variation in leaf character due to the gradient rate of NPK fertilizers is relied on mineral nutrition, especially nitrogen, which extremely could impact the dynamics of leaf surface formation according to estimated characters, confirming previous findings of Amanullah (2015); Bojović and Stojanović (2006) and Hou *et al.* (2020). Our data indicated that combined NPK fertilizers and augmented compost with lignocellulolytic fungi acting to colonize soil, mineralizing organic matter (priming effect) and PGP traits could compensate and enhance depleted mineral fertilizers, in harmony with Hellequin et al. (2019).

The establishment of inoculated fungi in the rhizosphere of wheat plants may interpret the enhancement of length and tips of roots through the production of secondary metabolites like harzianolide by *Trichoderma,* promoting better root development. Furthermore, *Trichoderma* produces indole acetic acid (IAA) and auxin-related substances to influence plant growth during early stages, including both length and tips of root development. It is empowered in controlling cell enlargement and division of tissue differentiation as well as phototropism and gravitropism (Zin and Badaluddin, 2020). The ability of *P. chrysosporium* as PGPF to improve roots and shoot growth of wheat plants was previously declared by Dief *et al.* (2021) as a result of the biopriming of wheat seeds.

The addition of NPK fertilizers stimulated the decomposition of organic matter is announced as the "priming effect" of soil organic matter, which is further enhanced by the action of fungal inoculate as a "positive priming effect" making the nutrients available for the crop at the right time unlike bulk addition of inorganic fertilizers which usually releases its constituents rapidly beyond the needs of growing plants. A combination of organic-inorganic nutrient sources is thought to improve the synchronization of nutrient release and subsequent uptake by the crop (Kimani and Lekasi, 2004). Another factor probably shared in the stimulation of N, P, and K uptake is the modulation of root architecture (

Table **5**) and their rhizodeposition that support rhizosphere colonization with plant growth-promoting microorganisms (PGPM) to enhance the accessibility of nutrients in the plant rhizosphere by the action of organic matter decomposition, called "rhizosphere priming" (Dijkstra *et al.*, 2013) and availability of inaccessible forms of nutrients N or P (Zin and Badaluddin, 2020), thereby enabling increased nutrients uptake.

The enhanced influence of applied fertilizer treatments on the straw yield of the wheat crop may be ascribed to the increases in plant height, which is consistence with Seleiman *et al.* (2021). They also attributed the positive effects of the high rate of N-fertilizers on the number of spikes/m^2 to the role of the available nutrients, which can improve the flag leaf area and total chlorophyll content leading to a rise in metabolites amount synthesized by the wheat plants for stimulating the tillers and spikes numbers/m^2. The increment in the number of kernels per spike due to mineral and organic fertilizers can be qualified as the increment in the spike length and the number of spikelets/spike, as concurred with Majeed *et al.* (2014) and Ibrahim et al. (2019). The enhancement in biological yield of wheat was previously achieved by Kabato *et al.* (2022) when integrated NP fertilizer with compost resulting in positive interactions between the two sources of nutrients to enhance nutrient supply due to the high content of organic carbon, nitrogen and available phosphorus.

The variations in wheat yield and associated components have depended widely on the source capacity of crop dry weight during earlier development of the vegetative stage as the outcome of the potential improvement in leaf features (**Error! Reference source not found.**) and root architecture (

Table **5**) in response to augmenting applied compost with lignocellulolytic fungi, especially with 75% NPK from full dose fertilizers, because both carbon assimilation is sustained by energy from photosynthesis that is not only required to enhance the growth of shoot but also to ensure continued nutrients uptake (wheat were evaluated based on straw yield, number of spikes per unit area, number of kernels per spike and biological yield resulting from cultivation on a sand soil with saprobic fungi-augmented organic matter and rates of NPK mineral fertilizers. The obtained data are represented in **Table (8)**. For straw yield, the number of kernels per spike along with biological yield revealed a significant increment due to the application of fungal processed compost by 14.89 and 11.33%, 14.67 and 3.69% along with 15.10 and 13.12% for such parameters during 1st and 2nd seasons, respectively.

) by roots, matching earlier statement of Rivera-Amado *et al.* (2020). The obtained results verify the findings of Moral *et al.* (1985), who found that the protein content and grain yield of six cultivars of winter barley, grown with two levels of nitrogen, were dependent on the crop dry weight or biomass created during the vegetative period (source capacity) which positively correlated with leaf area index. Also, the current findings of the harvest index are in agreement with Afridi *et al.* (2010), who stated that the harvest index has mainly relied on the above-ground dry matter and its variation along with environmental factors as well as the genetic makeup of plants. The obtained findings have been recently verified by Kabato *et al.* (2022) for grain yield, harvest index, and thousand seeds weight of wheat plant; as a result effect of combined application of NP along with compost on the soil pH, soil structure, available P, and total N, and might be other nutrients. They concluded sufficient evidence for enhancing the effectiveness of chemical fertilizer through the application of organic fertilizer, which acts to enhance beneficial microbial activity and improvement of soil fertility levels.

CONCLUSION

Under the current situation, the growth and productivity of wheat cultivated on sandy soil were enhanced due to processing compost using lignocellulolytic fungi inoculant, empowering us to diminish the applied amount of synthetic NPK fertilizers by 25% from the full dose. The corresponding enhancement has resulted from the incidence of decomposer for more decomposition of organic matter doing a positive priming effect by action of numerous active microorganisms of wheat rhizobiome. In turn, more nutrients and secondary metabolites have been released along with the growth promoters, potentially acting to improve the above- and below-ground parts of plants as a source capacity for high grain yield in eco-friendly and sustainable sound. Future research may be considering the heterogenicity of compost characters, and the varied efficiency of applied microorganisms as well as a cultivated plant to attain optimal conditions and extend the significant positive results taking into mind the economic and environmental considerations.

List of abbreviations

BMPs: Best Management Practic**es.**
SOM: Soil Organic Matter.
PGPF: Plant Growth Promoting Fungi**.**
WHC: Water Holding Capacity.
TTC: 2,3,5-triphenyl tetrazolium chloride.
TPF: Triphenyltetrazolium formazan.
PNP: *p*-nitrophenyl phosphate disodium hexahydrate.
LA: Leaf Area.
SLA: Specific Leaf Area.
SLW: Specific Leaf Weight.
DGCI: Dark Green Color Index.
RGB: Red, Green, Blue.

Conflict of Interest: The authors declare no conflict of interest

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إثراء الكمبوست بفطريات محللة لليجنوسيلولوز لزراعة القمح تحت مستويات مختلفة من الأسمدة المعدنية في التربة الرملية

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تم تنفيذ تجربتين عامليتين لدراسة تأثير السماد العضوي الذي تمت معالجته بإضافة لقاح الفطريات المحللة للجنوسيلوليت ، مقابل معدلات الأسمدة المعدنية NPK على نمو وإنتاجية القمح المزروع في التربة الرملية. يتكون اللقاح من نوعين من الفطريات المحللة للسيلولوز ، وهما *Trichoderma harzianum* و *Trichoderma viride* وفطر محلل للجنين هو *Phanerochaete chrysosporium* ، وتم استخدام اللقاح لمعالجة الكمبوست قبل قبل الزراعة. وتم اضافة ثلاثة معدلات من الأسمدة NPK 100٪ و 75٪ و 25٪ من الجرعة الموصى بها مع الكمبوست المعالَج أو غير المعالج. كشفت النتائج عن زيادة مكثقة للعدد الميكروبي الشامل والأنشطة المصاحبة له في منطقة جذور النباتات بسبب الكمبوست المعالَج والجرعة المتوسطة من الأسمدة NPK(75%). زاد الوزن الجاف للمجموع الخضري بشكل عام بالترتيب 100٪ NPK ‎50٪ NPK> 75٪ NPK>‎ ، مع وجود فرق غير معنوي بين المعالجات 100٪ و 75٪ عند اضافة مع الكمبوست المُعالَج. على الرغم من تفوق الجرعة الكاملة لمعاملة NPK ، فإن الاختلاف بينها وبين الأسمدة 75٪ NPK كان غير معنوي عند دمجها مع الكمبوست المعالَج لمحصول القش والحبوب ، ووزن 1000 حبة ، أو البروتين الكلى. و بناء على ما سبق فانه من الممكن تقليل الكمية المضافة من الأسمدة المعدنية NPK بنسبة 25 ٪ من الجرعة الكُلية من خلال اضافة الفطريات المحللة للجنين و السليلوز والتي تعمل على المزيد من تحلل المادة العضوية مما يؤدي إلى تأثير إيجابي في منطقة جذور نباتات القمح والتي تعمل على تحسين القياسات السابقة المأخوذة للنباتات المزروعة في التربة الرملية وبإنتاجية عالية من الحبوب مع مراعاة بأسلوب صديق للبيئة ومستدام.

الكلمات المفتاحية: نمو القمح, فطر رمي، الأسمدة المعدنية، الكمبوست المُعالَج، تأثير التهيئة.