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Impact of Mineral and Biological NP Fertilizers on Wheat Yield and Infestation by *Sitophilus oryzae* in Storage

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Abstract: Two field experiments were carried out at El-Balasy village, Sidi Salem Directorate, Kafr El-Sheikh Governorate, Egypt and Stored Product Pests department, Plant Protection Research Institute at Sakha Agricultural Research Stationduring the two successive seasons of 2019-20 and 2020-21 to study the effect of six NP fertilizer levels, *i.e.* 0, 25, 50, 75, 100 and 125 % of recommended dose of NP fertilizers (RDF), the RDF was 75 kg N and 30 kg P_2O_5 fed^{-1} and four biofertilizer treatments, *i.e.* without, Phosphobacteria 400 g/60 kg seeds fed^{-1} (PB), Azotobacter 400g/60 kg seeds fed^{-1} (AB) and mixed of Phosphobacteria 400 g and Azotobacter 400 g/60 kg seeds fed^{-1} (PB + AB) on growth, yield and kernels chemical properties of wheat variety Sakha 95 as well as the susceptibility of *S. oryzae* through a non-choice test. Increasing NP fertilizer levels from 0, 25, 50, 75 and 100 to 125 % RDF caused significant increments in mean values of all wheat traits under study except, crude fiber content and total carbohydrate content in wheat kernels during the both seasons, but the differences between NP fertilizer levels of 100 and 125 % RDF on mean values of most wheat traits were not reach the level of significance. Wheat seeds inoculation with mixed of PB + AB was the most effective treatment and significantly recorded the best values of growth, yield and kernels chemical properties of wheat traits under study in the both seasons. Wheat plants treated with 125 % RDF and seed inoculation with mixed of PB + AB gave the maximum mean values of plant height, No. of spikes m^{-2}, spike length, No. of kernels spike^{-1}, grain index, biological yield fed^{-1}, grain yield fed^{-1}, straw yield fed^{-1} and kernels chemical properties, *i.e.* nitrogen, crude protein, phosphorus, fat and ash contents in the both seasons. For insect infestation results showed the combined effect of NP and BF had the highest influence on the all studied parameters compared to the NP levels alone. The interaction between NP levels and BF treatments significantly decreased the number of emerged adults, % weight loss, % natural damage and increased the net grain yield and % germination. The interaction between NP levels and (PB + AB) treatment achieved the favorable effects on the all studied criteria followed by of (NP X PB) and (NP X AB). The level of 100 NP of RDF combined with the all biofertilizer treatments showed obvious distraction concerning the parameters under study among the other treatments. Eventually, the current study recommends the use of level 100 % level of NP (RDF) in combination with the (PB + AB) treatment. It could be concluded that planting wheat under soil fertilized by 125 % RDF and seed inoculation with mixed of PB + AB improved the production of wheat under the conditions of this region.

Key words: Wheat yield · NP fertilizers · Azotobacter · Phosphobacteria · *Sitophilus oryzae* · Non-choice · Germination

INTRODUCTION

Bread wheat (*Triticum aestivum*, L.) is the most important cereal crops in Egypt as well as over the world and covers more of the earth's surface, used in human food and animal feed. It is a staple food for more than one third of the world population.

The combined use of NP fertilizers plays an important role in wheat production. Application of NP in balanced share at proper time has great impact on wheat yield.

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Plant species, even varieties with in species vary in their behavior to obtain and utilize NP for grain production [1-9].

Nitrogen (N) is one of the primary nutrients, an integral part of the plant tissues and has both direct and indirect effects on the crop performance [9]. Nitrogen is a constituent of proteins, enzymes, coenzymes, nucleic acids, phytochromes and chlorophyll; it plays an important role in the biochemical processes of the plant. Therefore, it is one of the most required nutrients by wheat crops [10]. Nitrogen deficiency affects biomass production and solar radiation use efficiency by the plant, with a great impact on grain yield and its components [11]. Many reports indicated that nitrogen fertilizer has more influence on the most growth and yield wheat traits than any other plant nutrient because it is the nutrient most often deficient in the Egyptian soils. Thus, increasing application of nitrogen fertilizer levels led to significant increases in No. of days from planting to heading and maturity [12, 13, 14], plant height and No. of spikes m^{-2} [12, 14, 15, 16], spike length and No. of spikelets $spike^{-1}$ [16, 17, 18, 19], No. of kernels $spike^{-1}$ and 1000-kernel weight [4, 20, 21, 22], biological and straw yields [5, 23, 24, 25] in addition to grain yield and harvest index of wheat [6, 9, 26, 27, 28]. Increasing nitrogen fertilizer rates led to improve of kernels chemical properties of wheat [6, 9, 17, 22, 23, 25, 28].

Phosphorus is one of the major essential elements in plant life. These unique properties of phosphate produce water-stable anhydrides and esters that are important in energy storage and transfer in plant biochemical processes. Most notable are adenosine diphosphate and triphosphate (ADP and ATP). Energy is released when a terminal phosphate is split from ADP or ATP. The transfer of phosphate molecules to ATP from energy-transforming processes and from ATP to energy-requiring processes in the plants is known as phosphorylation. A portion of the energy derived from photosynthesis is conserved by phosphorylation of ADP to yield ATP in a process called photophosphorylation. Energy released during respiration is similarly harnessed in a process called oxidative phosphorylation. Beyond their role in energy-transferring processes, phosphate bonds serve as important linkage groups. Phosphate is a structural component of phospholipids, nucleic acids, nucleotides, coenzymes and phosphoproteins. Phospholipids are important in membrane structure. Nucleic acids of genes and chromosomes carry genetic material from cell to cell. As a monoester, phosphorus provides an essential ligand in enzymatic catalysis. Phytic acid, the hexaphosphate ester of myo-inositol phosphate, is the most common phosphorus reserve in grains [10, 29]. Several investigations reported that increasing phosphorus levels caused significant increase in No. of days from planting to heading and maturity [13, 30], plant height [30, 31], No. of spikes m^{-2} [14, 31], spike length and No. of spikelets $spike^{-1}$ [5, 32], No. of kernels $spike^{-1}$ and 1000-kernel weight [4, 9, 16, 18, 22], biological and straw yields [6, 15] in addition to grain yield and harvest index of wheat [27, 33, 34, 35]. Kernels chemical properties of wheat were improved by rising application of phosphorus fertilizers [6, 9, 22, 28, 34, 36].

In recent years, the world focused his attention to minimize environmental pollution and human health hazards, by reducing the use of synthetic fertilizers and chemicals in crops production [12, 36]. Biofertilizers are commonly called microbial inoculants which are capable of mobilizing important nutritional elements in the soil from non-usable to usable form by the crop plants through their biological processes [16, 37]. Biofertilizers due to its renewable, cheap and eco-friendly nature has gained increasing popularity in the past one decade in the field of agriculture and food production [36, 37]. The use of chemical fertilizers and pesticides has caused tremendous effect to the environment [13, 24]. Biofertilizers will help to solve such problems as increased salinity of soil and chemical run off from the agricultural field [18, 14]. It has been found to minimize the use of chemical fertilizers, improved soil fertility status and enhancing the crop production by their biological activity in the rhizosphere [38, 39]. Soil microbes have a significant role in keeping the biological balance of the soil, so they produce the essential CO_2 for compensating the resulting shortage of photosynthesis in the plant and keeping the gases equilibrium in the atmosphere [39, 40]. They can play a significant role in fixing atmospheric N and production of plant growth promoting substances. Existence of microbial communities like Azotobacter in the rhizosphere promotes the growth of the plant through the cycling and availability of nutrients, increasing the health of roots during the growth stage by competing with root pathogens and increasing the absorption of nutrients and water [38, 41]. [11, 20, 21] studied the effects of inoculation with Azotobacter on wheat and observed that inoculated wheat plants gave higher plant height, spikes per unit of area, grains per spike, grain weight, biological yield, grain yield and straw yield compared to non-inoculated wheat seeds. Some of investigations have suggested that integrated nutrient management strategies involving inoculation of seeds with Azotobacter in combination with chemical fertilizers result in improving both growth and yield of wheat [23, 28]. Phosphate

Solubilizing Bacteria (PSB) is used as biofertilizer. These organisms secrete various types of organic acids (carboxylic acid) lowering the pH in rhizosphere [38, 40]. The use of microorganisms helps to minimize use of much expensive phosphatic fertilizers. Experiments with PSB showed yield increase in wheat [18, 42, 41]. Using biofertilizers were induced improve of kernels chemical properties of wheat [23, 24, 28, 40, 41, 42].

Many research workers studied its nutritional requirements, where they found that chemical composition and technological characters response to the different levels and the kind of chemical and biofertilizers [38, 43]. The relationship between insect infestation and chemical composition of grains was investigated by many authors [44, 45, 46]. Wherever grain is stored, it is subject to infestation by different insect pests. Main four species which cause most of the damage to grain in storage are; the granary weevil (*Sitophilus granarius* L), the rice weevil (*Sitophilus oryzae* L.), the lesser grain borer (*Rhizopertha dominica* F.) and the Angoumois grain moth (*Sitotroga cerealella* Olive) [47, 48]. The future directions for research related to stored product insects and mites should include studying the detailed interactions in ecosystems in both the laboratory and the field and it should be broaden our boundaries of stored product ecosystems for a more complete understanding of pest activity [49].

The most important negative effects of the use of chemical insecticides are contamination of food and water sources. One alternative to the use of insecticides is planting of resistant cultivars which will limit the use of insecticides [50]. Research effort on the use of proper agronomic cultural practices as fertilization beside new cultivars with high yielding potentiality. Sowing date was one of the main agronomic practices that could directly effect on the level of insect infestation [51, 52]. The use of fertilizers as a yield booster has been reported [53-56]. Also, some macro-nutrients, nitrogen, phosphorus and potassium have received some attention in the study of plant resistant to insect pests. Fertilizers not only improve crop yield, but also influence crop suitability for insect development, depending on the type of fertilizers and pest species [57, 58, 59]. Research effort on the use of proper agronomic culture practices fertilization beside new cultivars with high yielding potentiality. Some macro nutrients, nitrogen, phosphorous and potassium have received some attention in the study of plant resistant to insect pests. Recent reports showed that the application of phosphorous reduced the population densities and damage of sucking bugs [60] and *Empoasca dolichi* Paoli [61]. In most of the rice growing areas in Asia, the greatest increases in population of major insect pests of rice were closely related to the long term excessive application of nitrogen fertilizer [62]. The green revolution initiated in the mind 1960s and characterized by the successful breeding and widespread adoption of new high yield varieties, pesticides and nitrogen fertilizers has doubled the production of many crops, such [63, 64] as rice, wheat and maize. The heavy application of nitrogen fertilizer rarely affects insect directly, however, it can alter or change morphological, biochemical and physiological characters of host plants improve conditions for herbivorous [65]. The quantity, quality and proportion of nutrients present in the food (including nitrogen) and the presence of secondary or anti nutritional compounds (all elochemicals) can have various impacts on the biology of insects, which affect their ability to contribute to the next generation and many have sublethal effects [66]. The all tested parameters of non-choice had highly significant positive correlation with N content (%), crude protein content (%), P content (%), K content (%) and ash content (%) of cowpea seeds. While, total carbohydrate content (%) and crude fiber content (%), which showed negative correlation with the aspects of cowpea beetles (F_1 and net weight loss) [67]. The information gained from this study could be important for avoiding the miss or over use of different fertilizers which would lead to produce more susceptible wheat grain varieties to infestation with the tested insect (*S. oryzae*). So, as a first step in this line of research, the goals of the present work were: to study the effect of different levels of nitrogen and phosphorous as well as biofertilizers applied to wheat variety in the field on the degree of infestation with *S. oryzae* in lab. The work also involved the study of change in the chemical composition and its relation to the degree of infestation with the mentioned insect.

Hence, considering the above facts, the present study was undertaken to study the effects of various levels of mineral nitrogen and phosphorus fertilizers and biofertilizer (Azotobacter and Phosphobacteria) inoculation on growth and yield of wheat variety of Sakha 95 as well as the susceptibility of *S. oryzae* through a non-choice test.

MATERIALS AND METHODS

Two field experiments were conducted during the both winter seasons of 2019-20 and 2020-21 at El-Balasy village, Sidi Salem Directorate, Kafr El-Sheikh Governorate, (31°33` North latitude, 30°78` East longitude and 3 m above the sea level) in the northern Delta of Egypt. The experiment was laid out in split plot design

Table 1: Chemical and physical characteristics of the experimental sit before conducting treatments during 2019-20 and 2020-21 seasons

				Chemical characteristics							
				Soluble cations meg l^{-1}				Soluble anions			
Season	Soil pH (1 :2.5)	EC(dSm^{-1})	Soil SAR (%)	Na^{+}	K^{+}	Ca^{2+}	Mg^{2+}	Co_3^{-2}	HCo_3^{-}	Cl^{-}	So_4^{-2}
2019-20	8.36	5.16	11.39	35.10	2.30	11.80	7.20	--	4.00	28.20	24.20
2020-21	8.25	4.52	10.56	30.70	1.50	10.50	6.40	--	3.50	24.80	20.80

Physical characteristics

	Particle size distribution						Soil moisture characteristics		
Season	Sand	Silt	Clay	Soil texture	Bulk density (Kg m^{-3})	Total porosity (%)	Field capacity	Wilting point	Available water
2019-20	10.26	32.56	57.18	Clay	1.38	47.92	40.80	20.25	20.55
2020-21	12.85	31.50	55.65	Clay	1.29	51.32	44.35	23.65	20.70

according to the procedure described by [68] and replicated thrice with six NP fertilizer levels (0, 25, 50, 75, 100 and 125 percent of recommended dose of NP fertilizers (RDF) in main plots, the RDF was 75 kg N and 30 kg P_2O_5 fed^{-1} and four biofertilizer treatments, *i.e.* without, seeds inoculation with Phosphobacteria 400 g/60 kg seeds fed^{-1} (PB), seeds inoculation with Azotobacter 400g/60 kg seeds fed^{-1} (AB) and seeds inoculation with mixed of Phosphobacteria 400 g and Azotobacter 400 g/60 kg seeds fed^{-1} (PB + AB) in sub-plots. Azotobacter and Phosphobacteria powders collected from General Authority for Agricultural Balance Fund, by Biofertilizers inoculum was prepared as Department of Microbiology of Soil and Water Research Institute, Agricultural Research Centre, Giza, Egypt. The phosphorous fertilizer was applied in form of calcium super phosphate (12.5 % P_2O_5) and applied during soil preparation in the two seasons. The nitrogen fertilizer was applied in form of urea (46 % N) and divided into two equal parts and applied before the first and second irrigations in each season.The preceding summer crop in the two seasons was rice (*Oryza sativa* L.). The gross and net sub plot size was 10.5 m^2 of 3.0 X 3.5 m including 15 rows 20 cm apart and 3.5 meter length. Bread wheat variety Sakha 95 was sown at row spacing 20 cm manually at seeding rate of 60 kg seed fed^{-1} on November 24th and harvest on May 9th in the both seasons. The other recommended agronomic practices of growing wheat were applied in the manner prevailing in the region were practiced.

Soil texture of the experimental site was clay and salty of pH nearly of 8.30. Soil samples were taken before wheat sowing to depth of 0-30 cm for chemical and mechanical properties analyses of the experimental soil were determined according to the standard procedures described by [69] and represented in Table 1.

Studied Parameters

Growth, Yield and its Components: Number of days from planting to 50 % heading and physiological maturity were determined from the whole plants in sub-plots. At harvest, wheat plants in one square meter from each sub-plot were harvested to determine No. of spikes m^{-2} and 1000-kernel weight in g. Then, ten fertile tillers from the previous one square meter were chosen randomly to estimate the plant height in cm, spike length in cm, No. of spikelets $spike^{-1}$ and No. of kernels $spike^{-1}$. While, biological, grain and straw yields in kg fed^{-1} and harvest index % were estimated from the whole wheat plants in sub-plot.

Kernels Chemical Properties: Wheat kernels samples were taken after harvest at random from each wheat kernels of ten fertile tillers to determine some kernels chemical properties: nitrogen content (%) according to the modified micro Kjeldahl method was determined according to the methods of Association of Official Analytical Chemists described in [70], crude protein content (%) was calculated by multiplying nitrogen content by 5.7 [71], phosphorus content (%) was determined colorimetrically according to the methods described in [70], fat content (%) was determined by using soxlet apparatus using petrolium ether as a solvent according to [72], crude fiber content (%) using the gravimetric method was done by [73], total carbohydrates content (%) in dry matter by using phenol-sulphuric acid method described by [74] as well as ash content (%) according to the methods described in [72, 75].

Mass Culturing of Rice Weevil (*Sitophilus oryzae*): A stock of *S. oryzae* was obtained from Stored Product Laboratory, Plant Protection Research Institute, Sakha Agriculture Research Station, Egypt. Wheat grains were used for rearing adults of *S. oryzae.* Wheat grains were heated at 50°C for 6 h to get rid of any prior insect infestations. Two glass jars, each of 500 ml were provided with 250 g wheat grains, 100 adults *S. oryzae* were transferred to the jars. All cultures were kept at 28 ± 2% and 65 ± 5% R.H, with light: dark photoperiod of 16:8h. The newly emerging adults (7-15 days) were collected by sieving the diets. Adult insects, used for all bioassays were of mixed sexes.

Susceptibility of Wheat Grain (Non-Choice) Infestation: To study the susceptibility of wheat kernels obtained from kernel sunder all treatments of study in the laboratory under non-choice conditions using 20 g of each treatment in glass jar (250 ml). Each jar was infested with ten mixed sexes of newly emerged adults (7-15 days old) and the jars were covered with muslin cloth, three replicates were used for each treatment. The adult emerged, % damage post one year, germination % and grain weight loss (%) were recorded according to the following equation:

$$\text{Grain weight loss (\%)} = \frac{Initial\ dry\ weight - Final\ dry\ weight}{Initial\ dry\ weight} \times 100$$

$$\text{\% Damage} = \frac{No.\ of\ infested\ seeds}{Total\ seeds} \times 100$$

Estimation of Net Grain Yield: In this study the net grain yield was determined by deducting the absolute value of % weight loss from the grain yield according to the followed equation:

Net grain yield (kg/fed) = Mean grain yield X [(100-Mean percent of damage)/100].

Statistical Analysis: Analysis of variance was carried out using MSTAT-C Statistical Software Package [76]. The comparison of means was investigated using Turkey's Honestly Significance Difference (H.S.D.) test at 0.05 % probability.

RESULTS AND DISCUSSION

Growth, Yield and its Components

Effect of NP Fertilizers: Results in Table 2 indicated that rising NP fertilizer levels from 0, 25, 50, 75 and 100 to 125 % RDF caused significant increments in mean values of all wheat traits under study during the 2019-20 and 2020-21 seasons, but the differences between NP fertilizer levels of 100 and 125 % RDF on mean values of most wheat traits were not reach the level of significance. Wheat plants under 125 % RDF significantly recorded the longest period from planting to heading (104.79 and 106.71 days) and maturity (147.54 and 149.04 days) as well as gave the highest mean values of plant height (113.17 and 117.08 cm), No. of spikes m^{-2} (401.00 and 425.00), spike length (10.66 and 11.32 cm), No. of spikelets spike^{-1} (19.77 and 19.85), No. of kernels spike^{-1} (62.16 and 67.60), grain index (54.24 and 55.41 g), biological yield fed^{-1} (8745.83 and 9535.00 kg), grain yield fed^{-1} (3344.17 and 3740.00 kg) and straw yield fed^{-1} (5401.67 and 5795.00 kg) in the both seasons, respectively. Meanwhile, the highest mean values of harvest index (39.66 and 40.26 %) were recorded from wheat plants treated with 100 % RDF in the both seasons, respectively. On the other hand, the shortest period from planting to heading (98.58 and 102.67days) and maturity (141.42 and 143.50 days) in addition to the minimummean values of plant height (75.83 and 78.25 cm), No. of spikes m^{-2} (272.67 and 295.50), spike length (6.83 and 7.05 cm), No. of spikelets spike^{-1} (16.88 and 17.63), No. of kernels spike^{-1} (47.99 and 47.72), weight of 1000-kernel (42.69 and 44.65 g), biological yield fed^{-1} (3673.33 and 4186.67 kg), grain yield fed^{-1} (1030.00 and 1228.75 kg), straw yield fed^{-1} (2643.33 and 2957.92 kg) and harvest index (27.96 and 29.27 %) in the both seasons, respectively were recorded from wheat plants under without application of NP fertilizer.The superiority ratios in the first season between wheat plants treated with 125 % RDF and each of 0, 25, 50, 75 and 100 % RDF were 49.23, 36.07, 22.12, 14.21 and 5.35 % for plant height; 47.07, 28.94, 20.97, 9.21 and 1.35 % for No. of spikes m^{-2}; 29.52, 21.40, 14.44, 7.22 and 2.11 % for No. of kernels spike^{-1}; 27.07, 18.15, 11.20, 6.33 and 1.79 % for 1000-kernel weight; 138.09, 70.35, 25.66, 15.76 and 7.63 % for biological yield fed^{-1}; 224.68, 107.60, 36.68, 18.10 and 3.72 % for grain yield fed^{-1} in addition to 104.35, 53.31, 19.68, 14.36 and 10.20 % for straw yield fed^{-1}, respectively. The excess ratios in the second season when wheat received 125 % RDF over each of 0, 25, 50, 75 and 100 % RDF were 49.63, 36.28, 24.23, 15.07 and 6.93 % for plant height; 43.82, 26.61, 17.03, 6.38 and 1.31 % for No. of spikes m^{-2}; 41.67, 31.33, 18.08, 8.12 and 1.85 % for No. of kernels spike^{-1}; 24.11, 17.03, 12.37, 6.84 and 1.03 % for 1000-kernel weight; 127.75, 68.66, 34.22, 13.46 and 4.26 % for biological yield fed^{-1}; 204.37, 104.65, 46.71, 16.72 and 1.55 % for grain yield fed^{-1} in addition to 95.91, 51.47, 27.22, 11.44 and 6.08 % for straw yield fed^{-1}, respectively. The increase in growth traits associated with increasing NP fertilizer levels may be attributed to the role of nitrogen and phosphorus in enhancement meristematic activity and cell division, which caused increases in number and size of cells in wheat stem. Also, the increases in grain yield fed^{-1} with increase in NP fertilizer levels may be attributed to the increases in kernels filling period, No. of spikes m^{-2}, spike length, No. of spikelets spike^{-1}, No. of kernels spike^{-1}, grain index, biological yield fed^{-1} and harvest index of wheat plants. Many investigators came out with similar results as [2, 3, 4, 5, 6, 7, 8, 9, 13, 14, 15, 16, 18, 22, 27].

Table 2: Mean values of wheat traits as affected by NP fertilizer levels during 2019-20 and 2020-21 seasons

Season	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
NP fertilizer levels (RDF)	Days to heading		Days to maturity		Plant height (cm)		No. of spikes m^{-2}		Spike length (cm)		No. of spikelets $spike^{-1}$	
0	98.58^{D}	102.67^{D}	141.42^{D}	143.50^{E}	75.83^{F}	78.25^{F}	272.67^{D}	295.50^{E}	6.83^{E}	7.05^{E}	16.88^{E}	17.63^{D}
25 %	100.42^{C}	104.33^{C}	143.29^{C}	145.00^{D}	83.17^{E}	85.92^{E}	311.00^{C}	335.67^{D}	7.85^{D}	8.23^{D}	17.58^{D}	18.22^{CD}
50 %	101.38^{C}	104.75^{BC}	144.21^{C}	146.13^{CD}	92.67^{D}	94.25^{D}	331.50^{C}	363.17^{C}	9.15^{C}	9.57^{C}	18.22^{C}	18.88^{BC}
75 %	102.71^{B}	105.75^{AB}	145.63^{B}	147.33^{BC}	99.08^{C}	101.75^{C}	367.17^{B}	399.50^{B}	9.87^{B}	10.59^{B}	18.95^{B}	19.38^{AB}
100 %	103.54^{B}	106.04^{A}	146.50^{B}	148.42^{AB}	107.42^{B}	109.50^{B}	395.67^{AB}	419.50^{AB}	10.53^{A}	11.09^{AB}	19.65^{A}	19.93^{A}
125 %	104.79^{A}	106.71^{A}	147.54^{A}	149.04^{A}	113.17^{A}	117.08^{A}	401.00^{A}	425.00^{A}	10.66^{A}	11.32^{A}	19.77^{A}	19.85^{A}
H.S.D. at 5 %	1.51	1.25	1.16	1.49	3.12	5.75	35.37	28.56	0.74	0.80	0.37	0.83
NP fertilizer levels (RDF)	No. of kernels $spike^{-1}$		1000-kernel weight (g)		Biological yield fed^{-1} (kg)		Grain yield fed^{-1} (kg)		Straw yield fed^{-1} (kg)		Harvest index (%)	
0	47.99^{E}	47.72^{D}	42.69^{E}	44.65^{E}	3673.33^{F}	4186.67^{E}	1030.00^{E}	1228.75^{E}	2643.33^{E}	2957.92^{E}	27.96^{E}	29.27^{E}
25 %	51.20^{D}	51.48^{CD}	45.91^{D}	47.35^{D}	5134.17^{E}	5653.33^{D}	1610.83^{D}	1827.50^{D}	3523.33^{D}	3825.83^{D}	31.37^{D}	32.33^{D}
50 %	54.32^{C}	57.25^{BC}	48.78^{C}	49.31^{C}	6960.00^{D}	7104.17^{C}	2446.67^{C}	2549.17^{C}	4513.33^{C}	4555.00^{C}	35.14^{C}	35.86^{C}
75 %	57.98^{B}	62.53^{AB}	51.01^{B}	51.87^{B}	7555.00^{C}	8404.17^{B}	2831.67^{B}	3204.17^{B}	4723.33^{BC}	5200.00^{B}	37.47^{B}	38.10^{B}
100 %	60.88^{A}	66.38^{A}	53.28^{A}	54.85^{A}	8125.83^{B}	9145.83^{AB}	3224.17^{A}	3682.92^{A}	4901.67^{B}	5462.92^{AB}	39.66^{A}	40.26^{A}
125 %	62.16^{A}	67.60^{A}	54.24^{A}	55.41^{A}	8745.83^{A}	9535.00^{A}	3344.17^{A}	3740.00^{A}	5401.67^{A}	5795.00^{A}	38.23^{AB}	39.21^{AB}
H.S.D. at 5 %	2.41	7.28	1.23	1.34	535.41	947.03	185.13	324.73	429.35	667.19	2.15	2.18

Table 3: Mean values of wheat traits as affected by biofertilizer treatments during 2019-20 and 2020-21 seasons

Season	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Biofertilizer treatments	Days to heading		Days to maturity		Plant height (cm)		No. of spikes m^{-2}		Spike length (cm)		No. of spikelets $spike^{-1}$	
Without	101.06^{D}	104.22^{D}	143.83^{D}	145.64^{D}	92.39^{D}	95.17^{D}	337.56^{D}	363.67^{D}	8.75^{C}	9.28^{D}	18.28^{D}	18.78D
PB	101.81^{C}	104.92^{C}	144.67^{C}	146.50^{C}	94.28^{C}	96.94^{C}	344.78^{C}	371.33^{C}	9.07^{B}	9.51^{C}	18.48^{C}	18.80^{C}
AB	102.17^{B}	105.33^{B}	145.03^{B}	146.81^{B}	96.33^{B}	98.39^{B}	350.00^{B}	376.78^{B}	9.31^{A}	9.80^{B}	18.59^{B}	19.13^{B}
PB + AB	102.58^{A}	105.69^{A}	145.53^{A}	147.33^{A}	97.89^{A}	100.67^{A}	353.67^{A}	380.44^{A}	9.47^{A}	9.98^{A}	18.69^{A}	19.22^{A}
H.S.D. at 5 %	0.18	0.20	0.21	0.28	0.86	0.63	2.31	2.14	0.18	0.15	0.08	0.36
Biofertilizer treatments	No. of kernels $spike^{-1}$		1000-kernel weight (g)		Biological yield fed^{-1} (kg)		Grain yield fed^{-1} (kg)		Straw yield fed^{-1} (kg)		Harvest index (%)	
Without	54.48^{D}	56.99^{D}	48.04^{D}	49.55^{D}	6417.78D	6988.89^{D}	2256.11^{D}	2505.00^{D}	4161.67^{D}	4483.89^{C}	33.95^{C}	34.75^{C}
PB	55.45^{C}	58.34^{C}	49.20^{C}	50.39^{C}	6653.33^{C}	7290.56^{C}	2388.89^{C}	2677.78^{C}	4264.44^{C}	4612.78^{B}	34.86^{B}	35.72^{B}
AB	56.18^{B}	59.62^{B}	49.76^{B}	50.95^{B}	6806.11^{B}	7476.11^{B}	2473.33^{B}	2783.89^{B}	4332.78^{B}	4692.22^{A}	35.35^{A}	36.26^{A}
PB + AB	56.90^{A}	60.35^{A}	50.27^{A}	51.40^{A}	6918.89^{A}	7597.22^{A}	2540.00^{A}	2855.00^{A}	4378.89^{A}	4742.22^{A}	35.73^{A}	36.63^{A}
H.S.D. at 5 %	0.32	0.61	0.21	0.21	38.42	84.19	29.54	32.36	37.38	68.87	0.41	0.38

Effect of Biofertilizers: A perusal of data presented in Table 3 revealed that, mean values of all vegetative growth, yield components and yield of wheat were significant increased by using biofertilizers alone or in combination over the control treatment in the 2019-20 and 2020-21 seasons. But, the differences between seed inoculation with AB and mixed of PB + AB in mean values of spike length in the first season, straw yield fed^{-1} in the second season and harvest index in the both seasons were not significant. Wheat seeds inoculation with mixed of PB + AB was the most effective treatment and significantly recorded the longest period from planting to heading (102.58 and 105.69 days) and maturity (145.53 and 147.33 days) as well as produced the maximum mean values of plant height (97.89 and 100.67 cm), No. of spikes m^{-2} (353.67 and 380.44), spike length (9.47 and 9.98 cm), No. of spikelets $spike^{-1}$ (18.69 and 19.22), No. of kernels $spike^{-1}$ (56.90 and 60.35), grain index (50.27 and 51.40 g), biological yield fed^{-1} (6918.89 and 7597.22 kg), grain yield fed^{-1} (2540.00 and 2855.00 kg), straw yield fed^{-1} (4378.89 and 4742.22 kg) and harvest index (35.73 and 36.63 %) in the both seasons, respectively. In the first season the superiority ratios when seed inoculation with PB, AB and mixed of PB + AB over the control treatment were 3.67, 6.05 and 7.81% for biological yield fed^{-1}; 5.89, 9.63 and 12.58 % for grain yield fed^{-1}; 2.47, 4.11 and 5.22 % straw yield fed^{-1} in addition to 2.67, 4.11 and 5.23 % for harvest index, respectively. The increases ratios in the second season when seed inoculation with PB, AB and mixed of PB + AB over the control treatment were 4.32, 6.97 and 8.70% for biological yield fed^{-1}; 6.90, 11.13 and 13.97 % for grain yield fed^{-1}; 2.87, 4.65 and 5.76 % straw yield fed^{-1} in addition to 2.78, 4.32 and 5.40 % for harvest index, respectively. Inoculation of wheat seeds with different combination of biofertilizers has synergic and additive effects on yield as they increase the fertilizer use efficiency as well as soil fertility by promoting soil microbial activities. Similar findings were also reported by [11, 24, 28, 37, 39, 41].

Effect of the Interaction: Results in Tables 4 and 5 revealed that the interaction between NP fertilizer levels and biofertilizer treatments had significant effect on mean values of plant height, No. of spikes m^{-2}, spike length, No. of kernels $spike^{-1}$, grain index, biological yield fed^{-1}, grain yield fed^{-1}, straw yield fed^{-1} and harvest index in both seasons. Meanwhile, mean values in No. of spikelets $spike^{-1}$ were not significantly affected by the interaction

Table 4: Mean values of days to heading, days to maturity, plant height, No. of spikes m^{-2}, spike length and No. of spikelets spike^{-3} of wheat as affected by the interaction between NP fertilizer levels and biofertilizer treatments during 2019-20 and 2020-21 seasons

Season		2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
NP fertilizer levels (RDF)	Biofertilizer treatments	Days to heading		Days to maturity		Plant height (cm)	
0	Without	97.50^{M}	101.50^{K}	140.17^{L}	142.50^{N}	73.00^{Q}	75.33^{R}
	PB	98.17^{LM}	102.17^{K}	140.83^{L}	143.17^{MN}	75.00^{PQ}	76.67^{R}
	AB	98.83^{KL}	103.00^{J}	141.83^{K}	143.67^{LM}	77.00^{OP}	79.00^{Q}
	PB + AB	99.83^{IJ}	104.00^{I}	142.83^{J}	144.67^{KL}	78.33^{O}	82.00^{P}
25 %	Without	99.17^{JK}	103.17^{J}	141.83^{K}	143.50^{MN}	79.67^{NO}	83.67^{OP}
	PB	100.50^{HI}	104.33^{HI}	143.50^{IJ}	145.17^{JK}	82.33^{MN}	85.33^{NO}
	AB	100.83^{H}	104.83^{FGH}	143.67^{HI}	145.50^{IJK}	84.33^{LM}	86.00^{N}
	PB + AB	101.17^{GH}	105.00^{FGH}	144.17^{GHI}	145.83^{HIJ}	86.33^{L}	88.67^{M}
50 %	Without	100.83^{H}	104.00^{I}	143.50^{IJ}	145.17^{JK}	89.67^{K}	91.00^{L}
	PB	101.17^{GH}	104.50^{GHI}	144.17^{GHI}	145.83^{HIJ}	91.67^{JK}	93.67^{K}
	AB	101.67^{FG}	105.00^{FGH}	144.33^{GH}	146.33^{GHI}	94.33^{IJ}	95.00^{K}
	PB + AB	101.83^{FG}	105.50^{DEF}	144.83^{FG}	147.17^{EFG}	95.00^{HI}	97.33^{J}
75 %	Without	102.17^{EF}	105.17^{EFG}	144.67^{G}	146.67^{FGH}	96.67^{HI}	99.33^{IJ}
	PB	102.67^{DE}	105.83^{CDE}	145.50^{EF}	147.17^{EFG}	97.67^{GH}	101.33^{HI}
	AB	102.83^{DE}	106.00^{BCD}	146.00^{DE}	147.50^{DEF}	100.00^{FG}	102.33^{GH}
	PB + AB	103.17^{CD}	106.00^{BCD}	146.33^{CD}	148.00^{CDE}	102.00^{F}	104.00^{G}
100 %	Without	102.83^{DE}	105.50^{DEF}	146.00^{DE}	147.83^{CDE}	105.33^{E}	107.00^{F}
	PB	103.33^{CD}	106.00^{BCD}	146.50^{CD}	148.50^{BCD}	107.00^{DE}	108.67^{EF}
	AB	103.83^{BC}	106.17^{BCD}	146.50^{CD}	148.67^{ABC}	108.00^{DE}	110.00^{E}
	PB + AB	104.17^{B}	106.50^{ABC}	147.00^{BC}	148.67^{ABC}	109.33^{CD}	112.33^{D}
125 %	Without	103.83^{BC}	106.00^{BCD}	146.83^{BC}	148.17^{B-E}	110.00^{CD}	114.67^{C}
	PB	105.00^{A}	106.67^{AB}	147.50^{AB}	149.17^{AB}	112.00^{BC}	116.00^{BC}
	AB	105.00^{A}	107.00^{A}	147.83^{A}	149.17^{AB}	114.33^{AB}	118.00^{AB}
	PB + AB	105.33^{A}	107.17^{A}	148.00^{A}	149.67^{A}	116.33^{A}	119.67^{A}
H.S.D. at 5 %		0.67	0.72	0.78	1.02	3.16	2.32
NP fertilizer levels (RDF)	Biofertilizer treatments	No. of spikes m^{-2}		Spike length (cm)		No. of spikelets spike^{-1}	
0	Without	268.00^{N}	290.00^{O}	6.31^{O}	6.58^{Q}	16.67	17.40
	PB	272.00^{N}	295.33^{NO}	6.78^{NO}	7.00^{PQ}	16.87	17.60
	AB	274.67^{N}	297.33^{NO}	6.98^{MN}	7.18^{OP}	16.93	17.73
	PB + AB	276.00^{N}	299.33^{N}	7.24^{MN}	7.44^{OP}	17.07	17.80
25 %	Without	300.67^{M}	324.67^{M}	7.17^{MN}	7.69^{NO}	17.33	18.07
	PB	308.67^{LM}	333.33^{L}	7.50^{LM}	8.11^{MN}	17.53	18.13
	AB	314.67^{KL}	340.00^{KL}	8.16^{KL}	8.42^{LM}	17.67	18.27
	PB + AB	320.00^{K}	344.67^{JK}	8.54^{JK}	8.69^{KL}	17.80	18.40
50 %	Without	322.67^{JK}	350.67^{J}	8.71^{IJK}	9.05^{JK}	18.00	18.67
	PB	330.00^{IJ}	358.67^{I}	9.16^{HIJ}	9.37^{IJ}	18.20	18.87
	AB	334.67^{HI}	368.67^{H}	9.31^{GHI}	9.83^{HI}	18.27	19.00
	PB + AB	338.67^{H}	374.67^{GH}	9.41^{FGH}	10.04^{GH}	18.40	19.00
75 %	Without	354.67^{G}	382.00^{G}	9.67^{E-H}	10.22^{FGH}	18.60	19.13
	PB	364.67^{F}	396.67^{F}	9.83^{D-G}	10.49^{EFG}	18.93	19.33
	AB	372.67^{EF}	407.33^{E}	9.94^{C-G}	10.72^{DEF}	19.07	19.53
	PB + AB	376.67^{E}	412.00^{DE}	10.04^{B-F}	10.91^{B-E}	19.20	19.53
100 %	Without	386.67^{D}	414.67^{CDE}	10.26^{A-E}	10.99^{A-E}	19.47	19.60
	PB	394.00^{CD}	419.33^{BCD}	10.49^{ABC}	10.80^{CDE}	19.67	19.87
	AB	399.33^{BC}	420.67^{BC}	10.65^{AB}	11.24^{A-D}	19.73	20.07
	PB + AB	402.67^{AB}	423.33^{AB}	10.73^{A}	11.31^{ABC}	19.73	20.20
125 %	Without	392.67^{CD}	420.00^{BC}	10.40^{A-D}	11.13^{A-D}	19.60	19.80
	PB	399.33^{BC}	424.67^{AB}	10.63^{AB}	11.31^{ABC}	19.67	19.00
	AB	404.00^{AB}	426.67^{AB}	10.78^{A}	11.37^{AB}	19.87	20.20
	PB + AB	408.00^{A}	428.67^{A}	10.83^{A}	11.48^{A}	19.93	20.40
H.S.D. at 5 %		8.45	7.84	0.66	0.54	N.S.	N.S.

Table 5: Mean values of No. of kernels spike^{-1}, 1000-kernel weight, biological yield fed^{-1}, grain yield fed^{-1}, straw yield fed^{-1} and harvest index of wheat as affected by the interaction between NP fertilizer levels and biofertilizer treatments during 2019-20 and 2020-21 seasons

Season		2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
NP fertilizer levels (RDF)	Biofertilizer treatments	No. of kernels spike^{-1}		1000-kernel weight (g)		Biological yield fed^{-1} (kg)	
0	Without	46.60^{T}	46.20^{Q}	41.08^{S}	43.84^{Q}	3200.00^{S}	3683.33^{Q}
	PB	47.97^{S}	47.13^{PQ}	42.64^{R}	44.44^{PQ}	3686.67^{R}	4173.33^{P}
	AB	48.30^{S}	48.47^{OP}	43.13^{QR}	44.96^{OP}	3856.67^{Q}	4373.33^{OP}
	PB + AB	49.10^{RS}	49.07^{NOP}	43.90^{PQ}	45.37^{O}	3950.00^{Q}	4516.67^{O}
25 %	Without	50.27^{QR}	49.90^{MNO}	44.43^{P}	46.58^{N}	4823.33^{P}	5346.67^{N}
	PB	50.77^{PQ}	50.90^{LMN}	45.87^{O}	47.11^{MN}	5086.67^{O}	5560.00^{MN}
	AB	51.50^{OP}	52.07^{LM}	46.55^{NO}	47.65^{LM}	5260.00^{N}	5760.00^{LM}
	PB + AB	52.27^{NO}	53.03^{KL}	46.78^{MN}	48.06^{KL}	5366.67^{N}	5946.67^{L}
50 %	Without	52.80^{MN}	54.63^{JK}	47.42^{M}	48.62^{JK}	6720.00^{M}	6776.67^{K}
	PB	53.87^{LM}	56.60^{IJ}	48.72^{L}	49.18^{IJ}	6913.33^{L}	7016.67^{JK}
	AB	54.97^{KL}	58.43^{HI}	49.23^{KL}	49.60^{I}	7046.67^{KL}	7250.00^{IJ}
	PB + AB	55.63^{JK}	59.33^{GH}	49.74^{JK}	49.85^{HI}	7160.00^{K}	7373.33^{I}
75 %	Without	56.67^{IJ}	60.67^{FG}	50.15^{IJ}	50.38^{H}	7380.00^{J}	7916.67^{H}
	PB	57.60^{HI}	62.17^{EF}	50.86^{HI}	51.72^{G}	7503.33^{IJ}	8406.67^{G}
	AB	58.43^{GH}	63.27^{DE}	51.18^{GH}	52.38^{FG}	7620.00^{HI}	8586.67^{FG}
	PB + AB	59.20^{FG}	64.00^{CDE}	51.86^{FG}	52.98^{EF}	7716.67^{H}	8706.67^{FG}
100 %	Without	59.90^{EF}	64.50^{CD}	52.12^{F}	53.45^{E}	7900.00^{G}	8890.00^{EF}
	PB	60.63^{DE}	65.93^{BC}	52.91^{E}	54.66^{CD}	8080.00^{F}	9113.33^{DE}
	AB	61.20^{CD}	67.10^{AB}	53.82^{CD}	55.41^{BC}	8203.33^{EF}	9270.00^{CD}
	PB + AB	61.77^{BCD}	67.97^{AB}	54.30^{ABC}	55.88^{AB}	8320.00^{E}	9310.00^{BCD}
125 %	Without	60.63^{DE}	66.03^{BC}	53.05^{DE}	54.44^{D}	8483.33^{D}	9320.00^{BCD}
	PB	61.87^{BC}	67.30^{AB}	54.21^{BC}	55.25^{BC}	8650.00^{C}	9473.33^{ABC}
	AB	62.70^{AB}	68.37^{A}	54.68^{AB}	55.69^{AB}	8850.00^{B}	9616.67^{AB}
	PB + AB	63.43^{A}	68.70^{A}	55.02^{A}	56.28^{A}	9000.00^{A}	9730.00^{A}
H.S.D. at 5 %		1.18	2.23	0.78	0.77	140.47	307.84
NP fertilizer levels (RDF)	Biofertilizer treatments	Grain yield fed^{-1} (kg)		Straw yield fed^{-1} (kg)		Harvest index (%)	
0	Without	853.33^{R}	1036.67^{S}	2346.67^{P}	2646.67^{I}	26.69^{M}	28.14^{N}
	PB	1023.33^{Q}	1213.33^{R}	2663.33^{O}	2960.00^{H}	27.75^{LM}	29.04^{MN}
	AB	1100.00^{PQ}	1303.33^{QR}	2756.67^{NO}	3070.00^{H}	28.49^{L}	29.77^{M}
	PB + AB	1143.33^{P}	1361.67^{Q}	2806.67^{N}	3155.00^{H}	28.92^{KL}	30.11^{LM}
25 %	Without	1463.33^{O}	1680.00^{P}	3360.00^{M}	3666.67^{G}	30.36^{JK}	31.44^{KL}
	PB	1590.00^{N}	1791.67^{OP}	3496.67^{L}	3768.33^{FG}	31.28^{IJ}	32.24^{JK}
	AB	1666.67^{MN}	1876.67^{NO}	3593.33^{KL}	3883.33^{FG}	31.71^{IJ}	32.61^{JK}
	PB + AB	1723.33^{M}	1961.67^{N}	3643.33^{K}	3985.00^{F}	32.13^{I}	33.04^{J}
50 %	Without	2266.67^{L}	2336.67^{M}	4453.33^{J}	4440.00^{E}	33.73^{H}	34.49^{I}
	PB	2443.33^{K}	2530.00^{L}	4470.00^{IJ}	4486.67^{E}	35.35^{G}	36.05^{H}
	AB	2510.00^{JK}	2633.33^{KL}	4536.67^{IJ}	4616.67^{E}	35.62^{G}	36.31^{H}
	PB + AB	2566.67^{J}	2696.67^{K}	4593.33^{HI}	4676.67^{E}	35.85^{FG}	36.56^{GH}
75 %	Without	2690.00^{I}	2936.67^{J}	4690.00^{GH}	4980.00^{D}	36.45^{EFG}	37.09^{FGH}
	PB	2796.67^{HI}	3186.67^{I}	4706.67^{GH}	5220.00^{CD}	37.28^{DEF}	37.91^{EFG}
	AB	2893.33^{GH}	3313.33^{H}	4726.67^{FGG}	5273.33^{BC}	37.97^{CD}	38.59^{DE}
	PB + AB	2946.67^{G}	3380.00^{GH}	4770.00^{FGH}	5326.67^{BC}	38.19^{CD}	38.83^{CDE}
100 %	Without	3056.67^{F}	3490.00^{FG}	4843.33^{DEF}	5400.00^{BC}	38.69^{BCD}	39.27^{B-E}
	PB	3183.33E	3645.00^{DE}	4896.67^{DE}	5468.33^{BC}	39.40^{ABC}	40.00^{ABC}
	AB	3276.67^{CDE}	3760.00^{BCD}	4926.67^{D}	5510.00^{B}	39.94^{AB}	40.56^{AB}
	PB + AB	3380.00^{ABC}	3836.67^{AB}	4940.00^{D}	5473.33^{B}	40.62^{A}	41.21^{A}
125 %	Without	3206.67^{DE}	3550.00^{EF}	5276.67^{C}	5770.00^{A}	37.80^{DE}	38.09^{EF}
	PB	3296.67^{BCD}	3700.00^{CD}	5353.33^{BC}	5773.33^{A}	38.11^{CD}	39.06^{CDE}
	AB	3393.33^{AB}	3816.67^{ABC}	5456.67^{AB}	5800.00^{A}	38.34^{CD}	39.69^{BCD}
	PB + AB	3480.00^{A}	3893.33^{A}	5520.00^{A}	5836.67^{A}	38.67^{BCD}	40.01^{ABC}
H.S.D. at 5 %		108.00	118.32	136.67	251.80	1.51	1.39

between NP fertilizer levels and biofertilizer treatments in the both seasons. Wheat plants treated with 125 % RDF and seed inoculation with mixed of PB + AB gave the maximum mean values of plant height (116.33 and 119.67 cm), No. of spikes m^{-2} (408.00 and 428.67), spike length (10.83 and 11.48 cm), No. of kernels $spike^{-1}$ (63.43 and 68.70), 1000-kernel weight (55.02 and 56.28 g), biological yield fed^{-1} (9000.00 and 9730.00 kg), grain yield fed^{-1} (3480.00 and 3893.33 kg) and straw yield fed^{-1} (5520.00 and 5836.67 kg) in addition to recorded the longest period from planting to heading (105.33 and 107.17 days) and maturity (148.00 and 149.67 days) in the both seasons, respectively. Meanwhile, the highest mean values of harvest index (40.62 and 41.21 %) were recorded from wheat plants treated with 100 % RDF and seed inoculation with mixed of PB + AB in the both seasons, respectively. On the other hand, the minimum mean values of plant height (73.00 and 75.33 cm), No. of spikes m^{-2} (268.00 and 290.00), spike length (6.31 and 6.58 cm), No. of kernels $spike^{-1}$ (46.60 and 46.20), grain index (41.08 and 43.84 g), biological yield fed^{-1} (3200.00 and 3683.33 kg), grain yield fed^{-1} (853.33 and 1036.67 kg), straw yield fed^{-1} (2346.67 and 2646.67 kg) and harvest index (26.69 and 28.14 %) in addition to recorded the shortest period from planting to heading (97.50 and 101.50 days) and maturity (140.17 and 142.50 days) in the both seasons, respectively were recorded from wheat plants under without adding NP fertilizer and biofertilizer treatment in the both seasons, respectively. These results in good accordance with those reported by [11, 12, 13, 14, 16, 18, 20, 21, 23, 24].

Kernels Chemical Properties

Effect of NP Fertilizers: Results presented in Table 6, clearly show that increasing NP fertilizer levels from 0, 25, 50, 75 and 100 to 125 % RDF caused significantly increases in most kernels chemical properties of wheat, except kernels crude fiber content and kernels total carbohydrate content were significantly decreased by increasing NP fertilizer levels during 2019-20 and 2020-21 seasons. Wheat plants treated with 125 % RDF significantly gave the highest kernels nitrogen content (2.248 and 2.294 %), kernels crude protein content (12.82 and 13.07 %), kernels phosphorus content (0.440 and 0.467 %), kernels fat content (1.877 and 2.166 %) and kernels ash content (4.891 and 5.162 %) in addition to recorded the lowest kernels crude fiber content (1.824 and 1.777 %) and kernels total carbohydrate content (81.72 and 80.14 %) in both seasons, respectively. The superiority ratios in the first season when wheat plants treated with 25, 50, 75, 100 and 125 % RDF over without NP fertilizer added were 10.77, 17.23, 22.97, 27.69 and 31.49 % for crude protein content in addition to 11.71, 20.25, 27.22, 33.23 and 39.24 % for kernels phosphorus content, respectively. The excess ratios in the second season when wheat plant received 25, 50, 75, 100 and 125 % RDF over without nitrogen and phosphorus application were 9.09, 14.72, 20.45, 25.40 and 29.15 % for kernels crude protein content in addition to 10.74, 19.63, 26.38, 34.36 and 43.25 % for kernels phosphorus content, respectively. The increases in kernels crude protein content and kernels phosphorus content by raising nitrogen and phosphorus levels may be due to the fact that nitrogen is essential for building up to the protoplasm amino acids and proteins also, phosphorus plays a vital role in several physiological processes via photosynthesis, respiration, energy storage and cell division/enlargement. These results are in agreement with that obtained by [6, 7, 8, 9, 22, 28].

Effect of Biofertilizers: Results presented in Table 7, revealed that, most chemical properties of wheat kernels were significant increased by using biofertilizers alone or in combination over the control treatment, except kernels crude fiber content was significantly decreased during the 2019-20 and 2020-21 seasons. Meanwhile, kernels total carbohydrate content was not significantly affected by biofertilizer treatments under study in the both seasons. Wheat seeds inoculation with mixed of PB + AB was the most effective treatment and significantly recorded the maximum kernels nitrogen content (2.071 and 2.111 %), kernels crude protein content (11.80 and 12.03 %), kernels phosphorus content (0.395 and 0.410 %), kernels fat content (1.568 and 1.776 %) and kernels ash content (4.536 and 4.697 %) in addition to recorded the lowest kernels crude fiber content (1.968 and 1.908 %). In the first season the superiority ratios when seeds inoculation with PB, AB and mixed of PB + AB over the control treatment were 1.69, 3.19 and 4.70% for kernels crude protein content in addition to 3.72, 1.33 and 5.05 % for kernels phosphorus content, respectively. The increases ratios in the second season when wheat seed inoculation with PB, AB and mixed of PB + AB over the control treatment were 1.65, 3.13 and 4.70% for bio kernels crude protein content in addition to 4.65, 1.55 and 5.94 % for kernels phosphorus content, respectively. Inoculation of wheat seeds with different combination of biofertilizers has synergic and additive effects on chemical properties of wheat kernels as they increase the fertilizer use efficiency as well as soil fertility by promoting soil microbial activities. Similar findings were also reported by [23, 24, 28, 41, 42].

Table 6: Mean values of kernels properties of wheat as affected by NP fertilizer levels during 2019-20 and 2020-21 seasons

Season	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
NP fertilizer levels (RDF)	N content (%)		Crude protein content (%)		P content (%)		Fat content (%)	
0	1.711^{F}	1.775^{F}	9.75^{F}	10.12^{F}	0.316^{F}	0.326^{F}	1.160^{F}	1.238^{F}
25 %	1.896^{E}	1.936^{E}	10.80^{E}	11.04^{E}	0.353^{E}	0.361^{E}	1.323^{E}	1.483^{E}
50 %	2.006^{D}	2.036^{D}	11.43^{D}	11.61^{D}	0.380^{D}	0.390^{D}	1.439^{D}	1.634^{D}
75 %	2.103^{C}	2.139^{C}	11.99^{C}	12.19^{C}	0.402^{C}	0.412^{C}	1.568^{C}	1.797^{C}
100 %	2.184^{B}	2.226^{B}	12.45^{B}	12.69^{B}	0.421^{B}	0.438^{B}	1.719^{B}	1.971^{B}
125 %	2.248^{A}	2.294^{A}	12.82^{A}	13.07^{A}	0.440^{A}	0.467^{A}	1.877^{A}	2.166^{A}
H.S.D. at 5 %	0.026	0.025	0.148	0.144	0.013	0.014	0.054	0.098

NP fertilizer levels (RDF)	Crude fiber content (%)		Total carbohydrate content (%)		Ash content (%)	
0	2.625^{A}	2.507^{A}	83.38^{A}	82.25^{A}	3.811^{F}	3.904^{F}
25 %	2.208^{B}	2.136^{B}	83.05^{B}	81.78^{B}	4.174^{E}	4.308^{E}
50 %	1.991^{C}	1.952^{C}	82.74^{C}	81.43^{C}	4.442^{D}	4.560^{D}
75 %	1.920^{CD}	1.864^{D}	82.37^{D}	81.04^{D}	4.641^{C}	4.748^{C}
100 %	1.887^{DE}	1.827^{DE}	82.01^{E}	80.60^{E}	4.774^{B}	4.940^{B}
125 %	1.824^{E}	1.777^{E}	81.72^{F}	80.14^{F}	4.891^{A}	5.162^{A}
H.S.D. at 5 %	0.099	0.077	0.206	0.167	0.113	0.101

Table 7: Mean values of kernels properties of wheat as affected by biofertilizer treatments during 2019-20 and 2020-21 seasons

Season	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Biofertilizer treatments	N content (%)		Crude protein content (%)		P content (%)		Fat content (%)	
Without	1.977^{D}	2.021^{D}	11.27^{D}	11.52^{D}	0.376^{D}	0.387^{D}	1.441^{D}	1.636^{C}
PB	2.010^{C}	2.055^{C}	11.46^{C}	11.71^{C}	0.390^{B}	0.405^{B}	1.510^{C}	1.703^{B}
AB	2.041^{B}	2.083^{B}	11.63^{B}	11.88^{B}	0.381^{C}	0.393^{C}	1.538^{B}	1.745^{A}
PB + AB	2.071^{A}	2.111^{A}	11.80^{A}	12.03^{A}	0.395^{A}	0.410^{A}	1.568^{A}	1.776^{A}
H.S.D. at 5 %	0.010	0.010	0.057	0.058	0.003	0.003	0.017	0.031

Biofertilizer treatments	Crude fiber content (%)		Total carbohydrate content (%)		Ash content (%)	
Without	2.198^{A}	2.126^{A}	82.65	81.33	4.356^{D}	4.497^{D}
PB	2.102^{B}	2.035^{B}	82.55	81.22	4.441^{C}	4.586^{C}
AB	2.036^{C}	1.973^{C}	82.52	81.17	4.489^{B}	4.636^{B}
PB + AB	1.968^{D}	1.908^{D}	82.46	81.10	4.536^{A}	4.697^{A}
H.S.D. at 5 %	0.021	0.021	N.S.	N.S.	0.016	0.025

Effect of the Interaction: Results in Table 8, revealed that the interaction between NP fertilizer levels and biofertilizer treatments had significant effect on most chemical properties of wheat kernels in both seasons except, kernels phosphorus content was not significantly affected in the first seasons. The highest kernels nitrogen content (2.283 and 2.320 %), kernels crude protein content (13.01 and 13.22 %), kernels phosphorus content (0.448 and 0.472 %), kernels fat content (1.921 and 2.248 %) and kernels ash content (4.931 and 5.222 %) in addition to the lowest kernels crude fiber content (1.761 and 1.696 %) and kernels total carbohydrate content (81.65 and 80.04 %) in the both seasons, respectively were recorded from wheat plants treated with 125 % RDF and seed inoculation with mixed of PB + AB. These results in good accordance with those reported by [23, 28].

Infestation of Wheat Kernels by *S. oryzae*: An experiment was conducted in laboratory to determine the susceptibility of wheat, *T. aestivum*, L. to insect infestation by *S. oryzae* adults through estimation the % weight loss, grain yield (kg fed^{-1}), net grain yield, % natural damage after one year postharvest and % germination. During the two successive seasons of 2019-20 and 2020-21 the wheat plants in field was fertilized by six levels of NP, *i.e.* 0, 25, 50, 75, 100 and 125 percent of recommended dose (RDF) with or without four biofertilizer treatments of phosphobacteria (PB), Azotobacter (AB) both 400g/60 kg seeds fed^{-1} as well as (PB + AB) at the same level mentioned above.

Effect of NP Fertilizers on the Parameters of Infestation by *S. oryzae*: Results summarized in Table 9, showed that the wheat grain obtained from the above treatments had

Table 8: Mean values of kernels properties of wheat as affected by the interaction between NP fertilizer levels and biofertilizer treatments during 2019-20 and 2020-21 seasons

Season		2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
NP fertilizer levels (RDF)	Biofertilizer treatments	N content (%)		Crude protein content (%)		P content (%)		Fat content (%)	
0	Without	1.622^{R}	1.672^{T}	9.25^{R}	9.53^{T}	0.302	0.307^{P}	0.976^{R}	1.108^{Q}
	PB	1.674^{Q}	1.746^{S}	9.54^{Q}	9.95^{S}	0.324	0.338^{NOP}	1.189^{Q}	1.231^{P}
	AB	1.734^{P}	1.807^{R}	9.89^{P}	10.30^{R}	0.308	0.315^{OP}	1.216^{Q}	1.285^{P}
	PB + AB	1.812^{O}	1.873^{Q}	10.33^{O}	10.68^{Q}	0.330	0.342^{MNO}	1.259^{P}	1.328^{OP}
25 %	Without	1.839^{O}	1.897^{PQ}	10.48^{O}	10.81^{PQ}	0.339	$0.346^{L\text{-}O}$	1.291^{OP}	1.415^{NO}
	PB	1.885^{N}	1.921^{OP}	10.74^{N}	10.95^{OP}	0.359	$0.368^{J\text{-}N}$	1.307^{NO}	1.473^{MN}
	AB	1.916^{MN}	1.951^{NO}	10.92^{MN}	11.12^{NO}	0.347	$0.356^{K\text{-}N}$	1.324^{N}	1.515^{LMN}
	PB + AB	1.942^{M}	1.975^{MN}	11.07^{M}	11.26^{MN}	0.365	$0.374^{I\text{-}M}$	1.371^{M}	1.528^{KLM}
50 %	Without	1.952^{M}	1.991^{LM}	11.13^{M}	11.35^{LM}	0.370	$0.379^{H\text{-}L}$	1.408^{L}	1.583^{JKL}
	PB	1.994^{L}	2.018^{KL}	11.37^{L}	11.51^{KL}	0.384	$0.395^{F\text{-}J}$	1.428^{KL}	1.627^{IJK}
	AB	2.028^{KL}	2.054^{JK}	11.56^{KL}	11.71^{JK}	0.375	$0.386^{G\text{-}K}$	1.444^{JK}	1.659^{IJ}
	PB + AB	2.049^{JK}	2.080^{IJ}	11.68^{JK}	11.86^{IJ}	0.391	$0.397^{E\text{-}J}$	1.474^{IJ}	1.668^{IJ}
75 %	Without	2.072^{IJ}	2.108^{HI}	11.81^{IJ}	12.02^{HI}	0.395	$0.404^{E\text{-}I}$	1.491^{I}	1.719^{HI}
	PB	2.094^{HI}	2.138^{GH}	11.94^{HI}	12.19^{GH}	0.405	$0.414^{D\text{-}G}$	1.554^{H}	1.791^{GH}
	AB	2.109^{GH}	2.144^{GH}	12.02^{GH}	12.22^{GH}	0.400	$0.408^{E\text{-}H}$	1.602^{G}	1.825^{FG}
	PB + AB	2.138^{FG}	2.165^{FG}	12.19^{FG}	12.34^{FG}	0.409	$0.420^{C\text{-}F}$	1.623^{G}	1.853^{EFG}
100 %	Without	2.159^{EF}	2.199^{EF}	12.31^{EF}	12.53^{EF}	0.416	$0.425^{C\text{-}F}$	1.670^{F}	1.927^{DEF}
	PB	2.180^{DE}	2.220^{DE}	12.42^{DE}	12.65^{DE}	0.424	$0.446^{A\text{-}D}$	1.707^{E}	1.951^{DE}
	AB	2.196^{CD}	2.237^{CD}	12.52^{CD}	12.75^{CD}	0.420	$0.429^{B\text{-}E}$	1.741^{D}	1.978^{CD}
	PB + AB	2.202^{CD}	2.250^{CD}	12.55^{CD}	12.82^{CD}	0.426	0.452^{ABC}	1.757^{D}	2.029^{CD}
125 %	Without	2.215^{CD}	2.261^{BC}	12.63^{CD}	12.89^{BC}	0.432	0.461^{AB}	1.811^{C}	2.060^{BC}
	PB	2.232^{BC}	2.288^{AB}	12.72^{BC}	13.04^{AB}	0.444	0.469^{A}	1.875^{B}	2.148^{AB}
	AB	2.263^{AB}	2.306^{A}	12.90^{AB}	13.14^{A}	0.436	0.465^{A}	1.902^{AB}	2.208^{A}
	PB + AB	2.283^{A}	2.320^{A}	13.01^{A}	13.22^{A}	0.448	0.472^{A}	1.921^{A}	2.248^{A}
H.S.D. at 5 %		0.037	0.038	0.209	0.212	N.S.	0.013	0.062	0.115

NP fertilizer levels (RDF)	Biofertilizer treatments	Crude fiber content (%)		Total carbohydrate content (%)		Ash content (%)	
0	Without	2.907^{A}	2.788^{A}	83.68^{A}	82.53^{A}	3.514^{S}	3.592^{P}
	PB	2.661^{B}	2.531^{B}	83.34^{B}	82.24^{B}	3.814^{R}	3.915^{O}
	AB	2.548^{C}	2.422^{C}	83.27^{BC}	82.16^{B}	3.920^{Q}	4.015^{NO}
	PB + AB	2.382^{D}	2.287^{D}	83.22^{C}	82.08^{B}	3.996^{P}	4.092^{N}
25 %	Without	2.421^{D}	2.329^{CD}	83.03^{D}	81.81^{C}	4.083^{O}	4.203^{M}
	PB	2.267^{E}	2.170^{E}	83.05^{D}	81.81^{C}	4.130^{N}	4.262^{LM}
	AB	2.129^{F}	2.067^{EF}	83.08^{D}	81.79^{C}	4.199^{M}	4.329^{L}
	PB + AB	2.015^{GH}	1.977^{FGH}	83.02^{D}	81.71^{C}	4.283^{L}	4.436^{K}
50 %	Without	2.042^{FG}	2.023^{FG}	82.85^{E}	81.50^{D}	4.377^{K}	4.521^{JK}
	PB	2.001^{GHI}	1.982^{FGH}	82.77^{EF}	81.45^{D}	4.421^{J}	4.531^{IJK}
	AB	$1.975^{G\text{-}J}$	1.922^{GHI}	82.72^{FG}	81.42^{D}	4.453^{J}	4.563^{IJ}
	PB + AB	$1.945^{G\text{-}K}$	$1.880^{H\text{-}K}$	82.63^{G}	81.35^{D}	4.517^{I}	4.627^{HI}
75 %	Without	$1.989^{G\text{-}J}$	1.909^{HIJ}	82.46^{H}	81.15^{E}	4.588^{H}	4.710^{GH}
	PB	$1.928^{H\text{-}L}$	$1.880^{H\text{-}K}$	82.39^{HI}	81.04^{EF}	4.635^{G}	4.740^{G}
	AB	$1.893^{J\text{-}M}$	$1.848^{I\text{-}L}$	82.34^{IJ}	81.02^{EF}	4.656^{FG}	4.760^{FG}
	PB + AB	1.868^{KLM}	1.817^{JKL}	82.28^{J}	80.96^{F}	4.686^{F}	4.782^{FG}
100 %	Without	$1.939^{G\text{-}L}$	$1.859^{I\text{-}L}$	82.08^{K}	80.74^{G}	4.731^{E}	4.848^{EF}
	PB	$1.907^{I\text{-}L}$	$1.843^{I\text{-}L}$	82.01^{KL}	80.62^{GH}	4.770^{D}	4.920^{DE}
	AB	1.867^{KLM}	$1.819^{I\text{-}L}$	81.99^{KL}	80.57^{GH}	4.790^{CD}	4.970^{D}
	PB + AB	1.836^{LMN}	1.788^{KLM}	81.97^{L}	80.46^{H}	4.804^{C}	5.023^{CD}
125 %	Without	$1.887^{J\text{-}M}$	$1.846^{I\text{-}L}$	81.81^{M}	80.27^{I}	4.844^{B}	5.107^{BC}
	PB	$1.847^{K\text{-}N}$	1.806^{JKL}	81.73^{M}	80.14^{IJ}	4.875^{B}	5.144^{AB}
	AB	1.801^{MN}	1.759^{LM}	81.69^{N}	80.09^{J}	4.913^{A}	5.177^{AB}
	PB + AB	1.761^{N}	1.696^{M}	81.65^{N}	80.04^{J}	4.931^{A}	5.222^{A}
H.S.D. at 5 %		0.078	0.075	0.118	0.184	0.059	0.090

Table 9: Mean values of No. of adults emergence (F1), kernels weight loss (%), grain yield (kg fed^{-1}), net grain yield (kg fed^{-1}), Natural damage (%) after one year post harvest and germination (%) of wheat as affected by NP fertilizer levels during 2019-20 and 2020-21 seasons

Season	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
	Non-choice (Susceptibility)					
NP fertilizer levels (RDF)	No. of adults emergence (F1)		Kernels weight loss (%)		Grain yield (kg fed^{-1})	
0	4.167^{A}	4.667^{A}	13.21^{A}	13.10^{A}	1030.00^{E}	1228.75^{E}
25 %	3.417^{B}	4.250^{A}	12.35^{B}	12.76^{AB}	1610.83^{D}	1827.50^{D}
50 %	2.667^{C}	3.000^{BC}	12.08^{BC}	12.58^{BC}	2446.67^{C}	2549.17^{C}
75 %	2.417^{C}	2.750^{C}	11.80^{BC}	12.30^{CD}	2831.67^{B}	3204.17^{B}
100 %	2.583^{C}	2.917^{BC}	11.44^{C}	11.93^{D}	3224.17^{A}	3682.92^{A}
125 %	3.750^{AB}	4.000^{AB}	12.13^{B}	12.42^{BC}	3344.17^{A}	3740.00^{A}
H.S.D. at 5 %	0.826	1.365	0.781	0.519	185.13	324.73
NP fertilizer levels (RDF)	Net grain yield (kg fed^{-1})		Natural damage (%)		Germination (%)	
0	895.58^{E}	1069.31^{E}	34.25^{B}	37.83^{B}	45.75^{C}	42.67^{C}
25 %	1413.04^{D}	1595.63^{D}	31.25^{C}	34.42^{C}	47.17^{C}	44.25^{C}
50 %	2152.59^{C}	2230.16^{C}	29.83^{D}	32.92^{D}	51.00^{B}	49.50^{B}
75 %	2498.53^{B}	2811.91^{B}	27.33^{E}	30.08^{E}	52.75^{AB}	50.17^{B}
100 %	2856.51^{A}	3244.74^{A}	26.67^{E}	29.42^{E}	53.67^{AB}	50.83^{AB}
125 %	2939.23^{A}	3277.00^{A}	38.25^{A}	42.17^{A}	55.58^{A}	52.83^{A}
H.S.D. at 5 %	157.92	285.86	1.143	1.634	4.391	2.919

Table 10: Mean values of No. of adults emergence (F1), kernels weight loss (%), grain yield (kg fed^{-1}), net grain yield (kg fed^{-1}), Natural damage (%) after one year post harvest and germination (%) as affected by biofertilizer treatments during 2019-20 and 2020-21 seasons

Season	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
	Non-choice (Susceptibility)					
Biofertilizer treatments	No. of adults emergence (F1)		Kernels weight loss (%)		Grain yield (kg fed^{-1})	
Without	3.833^{A}	4.444^{A}	14.32^{A}	14.76^{A}	2256.11^{D}	2505.00^{D}
PB	2.833^{B}	3.278^{C}	10.62^{C}	10.79^{C}	2388.89^{C}	2677.78^{C}
AB	3.444^{A}	3.944^{B}	13.61^{B}	14.06^{B}	2473.33^{B}	2783.89^{B}
PB + AB	2.556^{B}	2.722^{C}	10.12^{D}	10.46^{D}	2540.00^{A}	2855.00^{A}
H.S.D. at 5 %	0.414	0.414	0.411	0.172	29.54	32.36
Biofertilizer treatments	Net grain yield (kg fed^{-1})		Natural damage (%)		Germination (%)	
Without	1937.53^{C}	2139.41^{C}	42.44^{A}	46.83^{A}	43.44^{D}	41.56^{D}
PB	2141.86^{B}	2392.55^{B}	25.89^{C}	28.56^{C}	52.11^{C}	49.06^{C}
AB	2139.06^{B}	2394.03^{B}	34.39^{B}	37.89^{B}	53.44^{B}	50.67^{B}
PB + AB	2285.20^{A}	2559.85^{A}	22.33^{D}	24.61^{D}	54.94^{A}	52.22^{A}
H.S.D. at 5 %	27.68	28.90	0.842	0.958	1.349	1.365

significant differences between the all levels of treatments in concerning the number of adults emergence (F1), % weight loss, net grain yield, % natural damage and % germination. The level of 125 % RDF had the highest weight loss %, net grain yield (kg fed^{-1}), % natural damage after one year postharvest and % germination during the two successive seasons under study. Results cleared that there is no significant difference between the net yield of 100 and 125 % RDF treatments. In addition the 100 % RDF of NP achieved the lowest natural damage (%). Accordingly, the levels of 100 % RDF (NP) is considered the favorable to obtain the minimum of weight loss and the maximum of net grain yield (kg fed^{-1}) compared the other levels of NP fertilizers [77, 78, 79, 80, 81].

Effect of Biofertilizers on the Parameters of Infestation by *S. oryzae*: In the same text data acquired in Table 10, included the same parameters which were studied with NP treatments in the same two seasons 2019-20 and 2020-21 but with the biofertilizers PB and AB at the level of 400 g/60 kg seed fed^{-1}. Results obtained clarified a significant difference between the treatments. PB + AB produced the reduced number (2.556 and 2.722) in the both seasons, respectively of *S. oryzae* adults and % weight loss. Meanwhile, the same treatment (PB + AB) produced the highest net grain yield (2285.20 and 2559.85 kg fed^{-1}) and germination (54.94 and 52.22 %) and the lowest natural damage % (22.33 and 24.61 %) during the both seasons, respectively. Results showed that there is

Table 11: Mean values of No. of adults emergence (F1), kernels weight loss (%), grain yield (kg fed^{-1}), net grain yield (kg fed^{-1}), Natural damage (%) after one year post harvest and germination (%) as affected by the interaction between NP fertilizer levels and biofertilizer treatments during 2019-20 and 2020-21 seasons

Season		2019-20	2020-21	2019-20	2020-21		
		Non-choice (Susceptibility)				2019-20	2020-21
NP fertilizer levels (RDF)	Biofertilizer treatments	No. of adults emergence (F1)		Kernels weight loss (%)		Grain yield (kg fed^{-1})	
0	Without	4.667	5.333	15.40	15.50^{A}	853.33^{R}	1036.67^{S}
	PB	4.000	4.667	12.33	11.43^{G}	1023.33^{Q}	1213.33^{R}
	AB	4.333	5.000	14.47	14.37^{C-F}	1100.00^{PQ}	1303.33^{QR}
	PB + AB	3.667	3.667	10.63	11.10^{GH}	1143.33^{P}	1361.67^{Q}
25 %	Without	4.333	5.000	14.67	15.17^{AB}	1463.33^{O}	1680.00^{P}
	PB	3.000	4.000	10.97	11.07^{GHI}	1590.00^{N}	1791.67^{OP}
	AB	3.667	4.667	13.43	14.10^{DEF}	1666.67^{MN}	1876.67^{NO}
	PB + AB	2.667	3.333	10.33	10.70^{HIJ}	1723.33^{M}	1961.67^{N}
50 %	Without	3.333	3.667	14.20	14.73^{BC}	2266.67^{L}	2336.67^{M}
	PB	2.333	2.667	10.37	10.90^{G-J}	2443.33^{K}	2530.00^{L}
	AB	3.000	3.333	13.60	14.23^{C-F}	2510.00^{JK}	2633.33^{KL}
	PB + AB	2.000	2.333	10.13	10.47^{IJK}	2566.67^{J}	2696.67^{K}
75 %	Without	3.000	3.667	14.00	14.43^{CDE}	2690.00^{I}	2936.67^{J}
	PB	2.000	2.333	10.13	10.67^{HIJ}	2796.67^{HI}	3186.67^{I}
	AB	2.667	3.000	13.23	13.80^{F}	2893.33^{GH}	3313.33^{H}
	PB + AB	2.000	2.000	9.83	10.30^{JKL}	2946.67^{G}	3380.00^{GH}
100 %	Without	3.333	4.000	13.60	14.13^{C-F}	3056.67^{F}	3490.00^{FG}
	PB	2.333	2.333	9.47	9.90^{KL}	3183.33^{E}	3645.00^{DE}
	AB	2.667	3.333	13.07	13.87^{EF}	3276.67^{CDE}	3760.00^{BCD}
	PB + AB	2.000	2.000	9.63	9.83^{L}	3380.00^{ABC}	3836.67^{AB}
125 %	Without	4.333	5.000	14.07	14.57^{BCD}	3206.67^{DE}	3550.00^{EF}
	PB	3.333	3.667	10.43	10.77^{HIJ}	3296.67^{BCD}	3700.00^{CD}
	AB	4.333	4.333	13.87	14.00^{DEF}	3393.33^{AB}	3816.67^{ABC}
	PB + AB	3.000	3.000	10.17	10.33^{JKL}	3480.00^{A}	3893.33^{A}
H.S.D. at 5 %		N.S.	N.S.	N.S.	0.629	108.00	118.32
NP fertilizer levels (RDF)	Biofertilizer treatments	Net grain yield (kg fed^{-1})		Natural damage (%)		Germination (%)	
0	Without	722.14^{P}	875.93^{M}	48.00^{A}	53.00^{A}	39.33	36.33^{I}
	PB	897.23^{O}	1074.59^{L}	28.00^{IJ}	31.00^{IJ}	46.67	43.67^{FG}
	AB	941.22^{NO}	1116.30^{KL}	38.33^{DE}	42.33^{DE}	47.33	45.00^{EFG}
	PB + AB	1021.72^{N}	1210.41^{K}	22.67^{LM}	25.00^{LM}	49.67	45.67^{EFG}
25 %	Without	1248.41^{M}	1425.22^{J}	42.67^{BC}	47.00^{BC}	40.33	38.33^{HI}
	PB	1415.64^{L}	1593.46^{I}	26.33^{JK}	29.00^{JK}	47.67	45.33^{EFG}
	AB	1442.87^{L}	1612.07^{I}	35.00^{F}	38.67^{F}	49.33	45.67^{EFG}
	PB + AB	1545.24^{K}	1751.78^{H}	21.00^{MN}	23.00^{MN}	51.33	47.67^{DEF}
50 %	Without	1944.91^{J}	1992.67^{G}	41.33^{CD}	45.67^{CD}	43.67	43.67^{FG}
	PB	2190.23^{I}	2254.68^{F}	24.67^{KL}	27.33^{KL}	52.33	49.67^{CDE}
	AB	2168.55^{I}	2258.75^{F}	33.33^{GH}	36.67^{FG}	53.67	51.67^{BCD}
	PB + AB	2306.68^{H}	2414.55^{E}	20.00^{MN}	22.00^{MN}	54.33	53.00^{ABC}
75 %	Without	2313.26^{H}	2512.88^{E}	39.00^{D}	43.00^{D}	44.67	42.67^{GH}
	PB	2513.35^{G}	2846.79^{D}	21.00^{MN}	23.00^{MN}	54.33	51.33^{BCD}
	AB	2510.48^{G}	2856.08^{D}	30.33^{GHI}	33.33^{GHI}	55.67	52.67^{BC}
	PB + AB	2657.04^{EF}	3031.89^{C}	19.00^{N}	21.00^{N}	56.33	54.00^{ABC}
100 %	Without	2641.01^{F}	2996.82^{C}	38.33^{DE}	42.33^{DE}	45.67	43.67^{FG}
	PB	2881.98^{BC}	3284.13^{B}	20.00^{MN}	22.00^{MN}	54.33	51.00^{BCD}
	AB	2848.57^{CD}	3238.60^{B}	29.33^{HIJ}	32.33^{HIJ}	56.33	53.33^{ABC}
	PB + AB	3054.47^{A}	3459.40^{A}	19.00^{N}	21.00^{N}	58.33	55.33^{AB}
125 %	Without	2755.48^{DE}	3032.93^{C}	45.33^{AB}	50.00^{AB}	47.00	44.67^{FG}
	PB	2952.74^{B}	3301.63^{B}	35.33^{EF}	39.00^{EF}	57.33	53.33^{ABC}
	AB	2922.68^{BC}	3282.38^{B}	40.00^{CD}	44.00^{CD}	58.33	55.67^{AB}
	PB + AB	3126.03^{A}	3491.05^{A}	32.33^{FGH}	35.67^{FGH}	59.67	57.67^{A}
H.S.D. at 5 %		101.21	105.66	3.079	3.503	N.S.	4.989

no significant difference between PB and AB in both seasons. While mixture of PB + AB achieved significant difference by increasing the net grain yield compared to PB and AB separately. It is obviously showed that the (PB + AB) had the best effect for reducing weight loss and increasing the net grain yield followed by PB and AB with % weight loss of 10.62 and 13.61 and net grain yield (kg fed^{-1}) values of 2141.86 and 2139.06, respectively in the first season 2019-20. Results had the same trend in the second season 2020-21. Also results illustrated that the net grain yield in the second season 2020-21 continuously increased compared to the first season with the levels of treatments either with NP or biofertilizers. For example 100 % NP produced 2856.51 & 3244.74 kg fed^{-1} and the PB + AB produced 2285.20 & 2559.85 kg fed^{-1} in the two successive seasons, respectively [82, 83, 84].

Effect of the Interaction Between NP and BF on the Parameters of Infestation by *S. oryzae*: Results summarized in Table 11 explained that the net grain yield obtained from the mixture of NP and biofertilizers increased with the increasing level of NP fertilizers. For example the net grain yield increased from 1021.72 to 3126.03 kg fed^{-1} by zero to 125 % NP fertilizers in the first season. The interaction between NP and PB, AB and (PB + AB) led to greater of net grain yield than the levels of NP separately through the two seasons under study. The net grain yield of the second season with the all levels of NP fertilizers constantly increased about that of the first season. This results in consistent with that of [83, 85, 86, 87].

Correlation Studies Between Insect Traits and Chemical Properties of Wheat Kernels: Results in Table 12, showed that the simple correlation coefficients between insect traits [No. of adults emergence (F1), kernels weight loss (%), natural damage (%) and germination (%)] and chemical properties of wheat kernels [nitrogen content, crude protein content, phosphorus content, fat content, crude fiber content, total carbohydrate content and ash content] were significant from the all data during 2019-20 and 2020-21 seasons. No. of adults emergence (F1) was positive and significant correlated with crude fiber content (0.521^{**}) vice versa, was negative and significant correlated with nitrogen content (-0.411^{**}), crude protein content (-0.410^{**}), phosphorus content (-0.390^{**}), fat content (-0.260^{**}) and ash content (-0.392^{**}). Kernels weight loss (%) was positive and significant correlated with crude fiber content (0.366^{**}) vice versa, was negative and significant correlated with nitrogen content (-0.281^{**}), crude protein content (-0.281^{**}), phosphorus content (-0.323^{**}), fat content (-0.228^{**}) and ash content (-0.269^{**}). Natural damage (%) was positive and significant correlated with crude fiber content (0.298^{**}) vice versa, was negative with the remainder kernel chemical properties. Germination (%) was positive and significant correlated with nitrogen content (0.636^{**}), crude protein content (0.636^{**}), phosphorus content (0.616^{**}), fat content (0.555^{**}) and ash content (0.609^{**}) vice versa, was negative and significant correlated with crude fiber content (-0.654^{**}) and total carbohydrate content (-0.288^{**}). These results in good accordance with those reported by [67].

Number of Adults Emergence (F1) and Kernels Weight Loss Decreasing Percentages: The interaction between NP levels and BF treatments decreased the number of adults emergence and % weight loss in both seasons 2019-20 and 2020-21. NP levels with (PB +AB) treatment had the most interaction effect on the adult emergence of S. *oryzae* causing obviously decreasing in % weight loss (Table 13) followed by NP + PB and NP + AB, respectively. Generally, the 100 % NP (RDF) gave the best effects on the all parameter when it was mixed with the all biofertilizers treatments. Therefore and according to the present findings to current study recommend to use the 100 % NP (RDF) with the (PB + AB) biofertilizers treatment.

Net Grain Yield Increasing Percentage: Data summarized in Table 14, included the net grain yield (kg fed^{-1}) of both NP fertilizers (RDF) alone or in combination with biofertilizers without, PB, AB and PB + AB treatments at the all levels of NP (0, 25, 50, 75, 100 and 125 % of RDF). Results in Table 14, obviously showed that combination of NP (at the mentioned levels) with (PB + AB) treatment produced the highest net grain yield, 1021.72, 1545.24, 2306.68, 2657.04, 3054.47 and 3126.03 kg fed^{-1} respectively, with percent of increasing ranged between 13.45 to 41.48 % of NP fertilizers alone at the levels of 0, 25, 50, 75, 100 and 125 % RDF in the first season. Also, results explained that interaction between NP levels and biofertilizers AP and PB had an increasing percentage ranged between 7.16 to 24.25 % (PB) and 6.07 and 30.34 % (AB) of NP alone. The results in the second season involved in Table 14, had the same trend of the first season where the interaction between the levels of NP and PB + AB treatment achieved the highest of net grain yield with the highest increasing compared to NP levels alone. Results in Table 14, also illustrated significant differences in net grain yield of PB, AB and PB + AB with levels of NP fertilizers (0, 25, 50 and 75 % RDF),

Table 12: Simple correlation coefficients between insect traits and kernels chemical properties from the all data during 2019-20 and 2020-21 seasons

	Non-choice (Susceptibility)			
Parameter	No. of adults emergence (F1)	Kernels weight loss (%)	Natural damage (%)	Germination (%)
Nitrogen content (%)	-0.411**	-0.281**	-0.139	0.636**
Crude protein content (%)	-0.410**	-0.281**	-0.138	0.636**
Phosphorus content (%)	-0.390**	-0.323**	-0.136	0.616**
Fat content (%)	-0.260**	-0.228**	-0.045	0.555**
Crude fiber content (%)	0.521**	0.366**	0.298**	-0.654**
Total carbohydrate content (%)	0.084	0.104	-0.074	-0.288**
Ash content (%)	-0.392**	-0.269**	-0.127	0.609**

**. Correlation is significant at the 0.01 level (2-tailed)

Table 13: No. of adults emergence (F1) and kernels weight loss decreasing percentages arising from NP (RDF) levels + biofertilizers treatments against NP (RDF) alone in 2019-20 and 2020-21 seasons

	No. of adults emergence (F1) decreasing (Percentage)			Kernels weight loss decreasing percentage		
	Biofertilizer treatments					
NP fertilizers level (RDF)	PB	AB	PB + AB	PB	AB	PB + AB
2019-20 season						
0	14.29	7.14	21.43	19.91	6.06	30.95
25	30.77	15.38	38.46	25.23	8.41	29.55
50	30.00	10.00	40.00	27.00	4.23	28.64
75	33.33	11.11	33.33	27.62	5.48	29.76
100	30.00	20.00	40.00	30.39	3.92	29.17
125	23.08	0.00	30.77	25.83	1.42	27.73
2020-21 season						
0	12.50	6.25	31.25	26.24	7.31	28.39
25	20.00	6.67	33.33	27.03	7.03	29.45
50	27.27	9.09	36.36	26.02	3.39	28.96
75	36.36	18.18	45.45	26.10	4.39	28.64
100	41.67	16.67	50.00	29.95	1.89	30.42
125	26.67	13.33	40.00	26.09	3.89	29.06

$$\text{No. of adults emergence (F1) decreasing percentage} = \frac{\text{No. of adults emergence of NP} - \text{No. of adults emergence of (NP+BF)}}{\text{No. of adults emergence of NP}} \times 100$$ (According to Table 11)

$$\text{Kernels weight loss decreasing percentage} = \frac{\text{kernels weight loss \% of NP} - \text{kernels weight loss \% of (NP+BF)}}{\text{kernels weight loss \% of NP}} \times 100$$ (According to Table 11)

Table 14: Net grain yield increasing percentage arising from NP (RDF) levels + biofertilizers treatments against NP (RDF) alone in 2019-20 and 2020-21 seasons

NP fertilizers level (RDF)	Net grain yield (kg fed^{-1})				Percent of increasing		
				Biofertilizer treatments			
	Without	PB	AB	PB + AB	PB	AB	PB + AB
2019-20 season							
0	722.14	897.23	941.22	1021.72	24.25	30.34	41.48
25	1248.41	1415.64	1442.87	1545.24	13.40	15.58	23.78
50	1944.91	2190.23	2168.55	2306.68	12.61	11.50	18.60
75	2313.26	2513.35	2510.48	2657.04	8.65	8.53	14.86
100	2641.01	2881.98	2848.57	3054.47	9.12	7.86	15.66
125	2755.48	2952.74	2922.68	3126.03	7.16	6.07	13.45
2020-21 season							
0	875.93	1074.59	1116.30	1210.41	22.68	27.44	38.19
25	1425.22	1593.46	1612.07	1751.78	11.80	13.11	22.91
50	1992.67	2254.68	2258.75	2414.55	13.15	13.35	21.17
75	2512.88	2846.79	2856.08	3031.89	13.29	13.66	20.65
100	2996.82	3284.13	3238.60	3459.40	9.59	8.07	15.44
125	3032.93	3301.63	3282.38	3491.05	8.86	8.22	15.10

$$\text{Net grain yield increasing percentage} = \frac{\text{Grain yield of (NP + BF)} - \text{Grain yield of NP}}{\text{Grain yield of NP}} \times 100$$

Table 15: Natural damage decreasing percentage and germination increasing percentage arising from NP (RDF) levels + biofertilizers treatments against NP (RDF) alone in 2019-20 and 2020-21 seasons

NP fertilizers level (RDF)	Natural damage decreasing percentage			Germination increasing percentage		
			Biofertilizer treatments			
	PB	AB	PB + AB	PB	AB	PB + AB
			2019-20 season			
0	41.67	20.14	52.78	18.64	20.34	26.27
25	38.28	17.97	50.78	18.18	22.31	27.27
50	40.32	19.35	51.61	19.85	22.90	24.43
75	46.15	22.22	51.28	21.64	24.63	26.12
100	47.83	23.48	50.43	18.98	23.36	27.74
125	22.06	11.76	28.68	21.99	24.11	26.95
			2020-21 season			
0	41.51	20.13	52.83	20.18	23.85	25.69
25	38.30	17.73	51.06	18.26	19.13	24.35
50	40.15	19.71	51.82	13.74	18.32	21.37
75	46.51	22.48	51.16	20.31	23.44	26.56
100	48.03	23.62	50.39	16.79	22.14	26.72
125	22.00	12.00	28.67	19.40	24.63	29.10

$$\text{Natural damage decreasing percentage} = \frac{\text{Natural damage \% of NP} - \text{Natural damage \% of (NP+BF)}}{\text{Natural damage \% of NP}} \times 100$$ (According to Table 11)

$$\text{Germination increasing percentage} = \frac{\text{Germination \% of (NP+BF)} - \text{Germination \% of NP}}{\text{Germination \% of NP}} \times 100$$ (According to Table 11)

while there was no significant differences between the treatments of 100 and 125 NP (RDF). In general the interaction between NP levels and (PB + AB) treatment achieved the best net grain yield compared to the interaction of PB or AB with NP levels. In addition, the increasing of NP levels with the all biofertilizers treatments increased the net grain yield. There is no significant differences between NP levels of 100 and 125 % RDF combined with the all treatments either NP levels alone of NP + the other biofertilizers treatments at the all NP levels. NP level of 100 % RDF with (PB + AB) treatment gave net grain yield higher than that 125 % NP (RDF) alone or 125 % NP with AB or PB yield through two seasons.

Natural Damage Decreasing Percentage and Germination Increasing Percentage: Results acquired in Table 15, accentuated the percent of decreasing in natural damage after year of storage arising from the interaction between NP fertilizers at the all levels of (RDF) and the biofertilizers treatments (PB, AB and PB + AB). The all combination of NP with BF achieved significant decreasing in the natural damage compared to the NP alone. The interaction between levels of NP and (PB +AB) treatment decreased the natural damage. The percent of decreasing ranged between 28.68 to 52.78 % compared NP alone in the first season. The results in the second season 2020-21 had the same trend of the first one. Also results in Table 15, illustrated the combinations of NP with BF at the all levels and treatments increased the % germination between 18.18 to 21.99 % (BP), 20.34 to 24.63 % (AB) and 24.43 to 27.74 % with (PB +AB) in the first season and the result had the same direction in the second year.

Our results are in accordance with [88] studied the impact of certain groups of polyphenols (phenolic acid and alkylresorcinols) and lipophilic compounds (total lipids, fatty acids, sterols, tocols and carotenoids) on susceptibility of bread wheat (*T. aestivum* L.) kernels to *S. granarius* infestation. They reported that phenolic compounds act as natural plant pesticides and protect plants against external aggression and predators. These phenolic groups change according to the chemical composition in wheat cultivar which affect by genetic factors (species/cultivars)and by environmental conditions (mainly biotic stress).The phenomenon of various wheat cultivars susceptibility to pest damage is related to many chemical compounds, such the content of total protein or gluten, total lipids and cultivar lipids [77, 80, 81, 89] and physical kernel features, such as endosperm hardness or virtuosity and thickness of grain coat [78, 90, 91]. These relationships are much better understood for maize. According to [92], maize kernel resistance against maize weevil *S. zeamais* and large grain borer Prostephanus truncates is manifested by antibiosis and antixenosis mechanisms. The cited authors concluded that kernel-pest interaction are determined by biophysical factors (pericarp thickness (toughness, kernel hardness and endosperm virtuosity) and biochemical factors (hydroxycinnamic acids, hydroxyproline, rich glycoprotein, extensions, zeins, arabinoxylans, peroxidieses and phenolic acid amides) under control of genetic factors. The result of these interactions is kernel modification, which leads to limited accessibility or toxicity to invading pests [92]. Many research workers previously reported that the chemical composition of grains affect by many factors, the chemical and biofertilizers are involved in these factors.

The effects of four levels of phosphorus fertilizer application on insect population, damage and grain yield of cowpea varieties [79]. Results in the current study are agreement with that of [93] the reported that nitrogen plays an important role on the intensity of insect pests. They found a direct correlation of yield and nitrogen. Many studies suggest that fertilizer may affect the physiologically susceptibility of a crop to pest [94]. Nitrogen is essential to crop yield improvement and it can change crops ability to defend against herbivores [84]. There are appositive relationship between the physical-chemical characters of faba bean genotypes and infestation with *C. maculatus*. These characters must be taken in consideration for having resistant or tolerant seed of faba bean varieties to insect attack [95]. There are significant differences between cultivars in dry matter, crude fiber, phenols, tannins and physical traits, thickness of hull and seed coat percentages. They reported that these parameters affected the degree of *C. maculatus* infestation [96]. The biofertilizers have growth promoting activities in plant and may confer resistance to insect pests [83]. The effects of two chemical fertilizers, triple superphosphate (TSP) and urea and three biofertilizers (*Bradyrhizobium jabonica, Pseudomonas putida* and Mycorrhizal fungi) compared to control on resistance to cowpea pod on grain to *C. maculatus*. Results showed that *B. jabonica* can be suggested to utilize, as an alternative for chemical fertilizers, to minimize cowpea infestation by *C. maculatus*. Also, the treatment with chemical and biofertilizers increased the development times compared to control [87]. Theorganic and biofertilizers influenced on some soil chemical properties, which increased wheat productivity and decreased infestation level of some piercing-sucking pests in saline soil [97]. *Azotobacter chroococcum* inoculation can maximize the yield and enhance the resistance of maize to armyworm, *Mythimna separoto* under reduced N-fertilizer application. Furthermore, results indicated that there were significant correlations between armyworm response and chemical defense substances in the maize plants cultivated at reduced N-fertilizer application rate and with *A. chroococcum* inoculation [84]. The inoculation of bio-organic fertilizer and / or chemical fertilizer, nitrogen changed some physical and chemical characters of tested wheat varieties compared with control. Therefore the differences for susceptibility of insect infestation under the different level of nitrogen fertilizer may be due to this cause [82]. It is reported that the induced resistance in plants by soil-born microorganisms can reduce population growth of herbivorous insects [85, 86]. The investigation conducted by [98] was in disagreement with our findings where they reported that wheat preferences and offspring production of *S. zeamais* were not significantly affected by different nitrogen fertilizer level. This difference perhaps comes back to the types of species under study.

The influence of nutritional composition of grains of different corn cultivars produced under different fertilization systems on resistance of dry kernel against the maize weevil *S. zeamais*. They found that in absence of fertilization all the cultivars, in general present a minor contents of leave minerals .the highest grain production was obtained from the plot with combined fertilization and the lowest in the unfertilized plot. Concerning the influence of nutritional composition on the *S. zeamais,* the results did not indicate the existence of a significant effect of the grain composition on development and susceptibility index [99]. This result differ that of our result due to the difference type of crop and insect pest under study.

CONCLUSION

On the basis of two seasons study during 2019-20 and 2020-21, it can be concluded that increasing NP fertilizer doses from 0 % RDF to 125 % RDF increased the growth, yield, yield components as well as chemical properties of wheat kernels. Inoculation of PB + AB recorded significantly higher growth, yield attributes and yield as well as improved kernels chimerical properties of wheat kernels. It could be concluded that planting wheat under soil fertilized by 125 % RDF and seed inoculation with mixed of PB + AB in order to improve the production of wheat under the condition of El-Balasy village, Sidi Salem Directorate, Kafr El-Sheikh Governorate, Egypt. In this study, mineral fertilization rates between zero and 125 % of the recommended dose on wheat seeds previously inoculated with different biological fertilizers, single or combined, were evaluated on the sensitivity of the resulting grain to rice weevil, *S. oryzae* infection after by measuring some different parameters. The results showed that wheat seeds previously inoculated with different doses of biofertilizers individually or jointly and which were fertilized in the field at a rate of 100 % of the recommended dose led to better results than if the mineral fertilizers were used alone, which gave the highest net yield and lowest percentage of infestation by the insect under study.

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