Academic Journal of Entomology 16 (2): 46-69, 2023
ISSN 1995-8994

DOI: 10.5829/idosi.aje.2023.46.69

Phosphate and Potassium Fertilizers as Factors Affecting All Yield Traits and Susceptibility of Infestation of Three Wheat Varieties by *Sitophilus oryzae* Post-Harvest

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Abstract: This study was carried out to evaluate the performance of three bread wheat varieties (Misr 3, Sakha 95 and Giza 171) under three phosphorous fertilizer rates (0, 15 and 30 kg P_2O_5 fed^{-1}) and three potassium fertilizer rates (0, 24 and 48 kg K_2O fed^{-1}) on growth, yield, yield component and kernels chemical properties as well as two types of laboratory experiments were designed which are free-choice (preferability) and no free-choice (susceptibility) to measure the effect of different rates of phosphorus and potassium fertilization in the field on the degree of infestation of thee tested wheat varieties with rice weevil, *S. oryzae* adults after harvest.. The experiment was conducted at El-Balasy village, Sidi Salem Directorate, Kafr El-Sheikh Governorate, Egypt, during the two successive seasons of 2019-20 and 2020-21. The differences between the studied wheat varieties in all traits were significant in the both seasons. Misr 3 variety significantly recorded the maximum No. of spikes m^{-2}, biological yield fed^{-1}, straw yield fed^{-1}, kernel nitrogen content and kernel crude protein content in the both seasons. The highest plant height, grain yield fed^{-1}, harvest index, kernel phosphorus content, kernel potassium content, kernel fat content, kernel crude fiber content and kernel ash content as well as the shortest period from planting to maturity were obtained from Sakha 95 variety in both seasons. Giza 171 variety recorded the highest spike length, No. of spikelets spike^{-1}, No. of kernels spike^{-1}, 1000-kernel weight and kernel total carbohydrate content in the both seasons. Increasing phosphorus fertilizer rates from 0 up to 30 kg P_2O_5 fed^{-1} caused significant increments all growth, yield, yield components and kernels chemical properties of wheat except, kernel crude fiber content and kernel total carbohydrate content. Wheat plants treated with 30 kg P_2O_5 fed^{-1} gave significantly the greatest values of wheat traits in the both seasons. The higher potassium rate (48 kg K_2O fed^{-1}) was more effective in increasing values of all growth, yield, yield component and kernels chemical properties except, kernel crude fiber content and kernel total carbohydrate content in the both seasons. The interactions between treatments of Sakha 95 X 30 kg P_2O_5 fed^{-1}, Sakha 95 X 48 kg K_2O fed^{-1}, 30 kg P_2O_5 fed^{-1} X 48 kg K_2O fed^{-1} and Sakha 95 X 30 Kg P_2O_5 fed^{-1} X 48 kg K_2O fed^{-1} were significantly recorded the greatest grain yield fed^{-1} as compared with the others interactions in the both seasons. Results show the ideal rates of fertilization that gives the lowest infestation rate, and the statement of the three highest tolerance varieties. Results have yielded that whether the rates of fertilizers and wheat varieties showed significant effect on the most tested criteria. These significant effects of fertilizer rate demonstrate the reasonable rate responsible for the tolerant of wheat variety to insect infestation by *S. oryzae*. Results obtained proved that the interaction among variety Sakha 95, 30 kg P_2O_5 and 48 kg K_2O fed^{-1} rate was the premier treatment which achieved the highest net grain yield (after subtract the % weight loss) and the least wheat weight loss resulting from the least No. of emerged adults. In general, Sakha 95 variety was the premier at the all rates of the two tested fertilizers in the two seasons of experiment in storage. Misr 3 follows the Sakha 95 and Giza 171 had the later position concerning the tolerant to infestation or the net grain yield (kg fed^{-1}). From the obtained results of this study it could be concluded that planting wheat variety of Sakha 95 under soil fertilized by 30 kg P_2O_5 and 48 kg K_2O

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fed^{-1} achieved maximum wheat grain yield fed^{-1} and achieved the highest net grain yield (after subtract the % weight loss) as well as the least wheat weight loss resulting from the least No. of emerged adults under the conditions of this region.

Key words: Wheat varieties · Phosphorus fertilizer · Potassium fertilizer · *Sitophilus oryzae* · Preferability · Susceptibility · 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. World average cultivated area of wheat in 2020 year (www.fao.org) reached 521.445 million fed; the total production was 760.926 million tonnes and an average productivity of 1459.25 kg fed^{-1}. The growing area of wheat in Egypt was about 3.262 million fed with a total grain yield of 9.000 million tonnes by average grain yield was about 2758.640 kg fed^{-1}. The total production supplies 50 % of the require consumption with a reduction gap of 50 % which has to be filled via importation.

Wheat yield can be increased by the use of recently developed high yielding, disease resistant varieties and appropriate production technologies such as nutrients management. Wheat yield potential could be sustained through the use of high yielding varieties with application of the best agronomic practices such as nitrogen and phosphorus fertilizer rates. Varietal differences among wheat varieties have been reported by many investigators found that significant differences among the wheat varieties on No. of days from planting to heading and maturity [1-4], plant height and No. of spikes m^{-2} [5-8], spike length, No. of spikelets spike^{-1} and No. of kernels spike^{-1} [9-12], 1000-kernel weight, biological and straw yields [13-16], grain yield and harvest index [17-20] in addition to kernels chemical properties of wheat [1, 5, 19, 20].

Phosphorus is essential for many physiological processes, such as storage of energy and its transfer, respiration, photosynthesis, cell division and cell enlargement etc. Phosphorous is involved in the synthesis of energy rich phosphate compound such as adenosine triphosphate (ATP) and adenosine diphosphate (ADP) which derive various biochemical reactions within the plant. Phosphorus role in plant is not limited to metabolic reactions. Phosphorus is a structural component of nucleic acid (DNA, RNA) nucleotide, phospholipids and phosphoprotiens. The movement of applied phosphatic fertilizer in soil is just only 3-4 cm. Consequently, it is hardly available to the extent of 15-20% to the plant. The rest goes to waste from immediate crop being fixed in soil [9]. Phosphorus application at proper time, in optimum quantity through proper method of application is essential to increase crop production and its sustainability [21, 22]. Several investigations reported that increasing phosphorus rates caused significant increase in No. of days from planting to heading, maturity and plant height [5, 15, 21, 23], No. of spikes m^{-2} and spike length [1, 15, 24], No. of spikelets spike^{-1} and No. of kernels spike^{-1} [12, 14, 17, 25, 26, 27], 1000-kernel weight, biological and straw yields [10, 19, 20, 28, 29, 30], grain yield and harvest index [31-35] in addition to nitrogen content, crude protein content, phosphorus content, potassium content, fat content and ash content in wheat kernels [5, 19, 32]. On the contrary, mean values of kernel crude fiber content and kernel total carbohydrate content were decreased [13, 24, 33].

Potassium is among the macro nutrients which are taken up by plants in large amount. It plays significant roles in transportation of water, nutrients, nitrogen utilization, and stimulation of early growth and in insect and disease resistance [36]. Potassium is also important in the transportation of prepared food from the leaves to the rest of the plant parts, quality of seeds and fruits, strengthens the roots, stem and branches of plants and reduce lodging [37]. Potassium involved in many physiological processes, photosynthesis, protein synthesis and enzyme activation can have direct consequences on crop productivity in addition to reduced amount of photosynthetic source material with a reduction in the photosynthetic rate/unit leaf area, and the result is an overall reduction in the amount of photosynthetic assimilates available for growth [38]. Potassium deficiency can lead to a reduction in both the No. of leaves produced and the size of individual leaves [21]. Potassium fertilization had shown yield improvement of crops in various areas of the world [39, 40]. Research findings indicated that potassium fertilizer increased period from planting to heading and maturity [2, 7, 32], plant height and No. of spikes m^{-2} [41, 42], spike length and No. of spikelets spike^{-1} [3, 43], No. of kernels spike^{-1} and 1000-kernel weight [6, 28, 44], biological and straw yields [18, 45], grain yield and harvest index [24, 27, 46] as well as nitrogen content, crude protein content, phosphorus content, potassium content, fat content and ash content in wheat kernels [6, 13, 24]. On the contrary, mean values of kernel crude fiber content and kernel total carbohydrate content were decreased [32, 42].

With reference to the important role of phosphorous and potassium in crop productivity, this research study was planned to evaluate the effect of various phosphorous and potassium levels on wheat varieties (Misr 3, Sakha 95 and Giza 171). Among the goals of botanists in the breeding process for varieties that have the ability to withstand pest infestation, whether in the field or in the store. There are some factors that control the plants ability to withstand pest infestation, including two main factors: genetic factors and environmental conditions where the plant cannot express its genetic characteristics, whether it tolerates infestation or increase in yield except with the help of environmental factors, including climatic factors such as heat and humidity, in addition to agricultural operations such as irrigation, tillage, fertilization, and others. Post-harvest losses of cereal grain during storage may be as high as 83 % of mass, especially in tropical and subtropical areas [47]. According to FAO estimates grain losses from pests are about 96 million tonnes annually [48]. Chemical control, although most effective, is very costly, hazardous and unsustainable. Investigation of other control options such as cultural practices that are environment friendly is critically important. Even though recent reports showed that the application of phosphorus reduced the population densities and damage of pod-sucking bugs [49] and *Empoasca dolichi* paoil [50, 51] not much is known of the its effect on other insect pests of cowpea. The use of fertilizers as a yield booster has been reported [52-54]. Also, some macro-nutrients, nitrogen, phosphorous and potassium has received some attention in the study of plant resistance to insect pests. Fertilizers no only improve crop yield but also influence crop suitability for insect development, depending on the type of fertilizer and pest species [55-57]. In the interior of the infested kernels, there are moults or dead individuals. Milling products made from grains heavily infested by *S. granarius* are harmful to humans and animals [58]. Additionally, the infestation by *S. granarius* results in an increase in kernel moisture content and temperature, which contributes to an increase in enzyme activity, facilitates the invasion of secondary insect pests, bacteria mites and fungi [59, 60].

The current study aims to demonstrate the importance of chemical fertilization in the plants ability to withstand or resist pest infestation, as these results in increased production. Accordingly, the current study was designed to evaluate some levels of phosphorus and potassium fertilization and to determine the optimal dose to obtain a strong plant that tolerates infestation, and thus results in increased production as this contributes to the process breeding for resistance. These findings are in conformity with past works on phosphorus and potassium nutrition in wheat varieties.

MATERIALS AND METHODS

Two field experiments were carried out 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, during the two successive growing seasons of 2019-20 and 2020-21. This study was to evaluate the performance of three bread wheat varieties (Misr 3, Sakha 95 and Giza 171) and the name and pedigree of these varieties are showed in Table (1) under three phosphorous fertilizer rates (0, 15 and 30 kg P_2O_5 fed^{-1}) and three potassium fertilizer rates (0, 24 and 48 kg K_2O fed^{-1}) on the vegetative growth, yield components and yield of wheat. Wheat seeds of the three wheat varieties were secured every three seasons from Field Crop Institute, Sakha Agriculture Research Station, Agricultural Research Center (ARC), Giza, Egypt. Bread wheat varieties were developed by Wheat Research Section, Field Crop Research Institute, ARC, Giza, Egypt. The phosphorous and potassium fertilizers were applied in form of calcium super phosphate (12.5 % P_2O_5) and potassium sulphate (48% K_2O) and applied in one dose during soil preparation and before the first irrigation in the both seasons, respectively.

Table 1: Name and pedigree of the three studied Egyptian bread wheat varieties

Variety	Pedigree	Selection history
Misr 3	ATTILA*2/PBW65*2/KACHU	CMSS06Y00582T-099TOPM-099Y-099ZTM-099Y-099M-10WGY-0B-0EGY
Sakha 95	PASTOR // SITE / MO /3/ CHEN / AEGILOPS SQUARROSA (TAUS) // BCN /4/ WBLL1	CMSA01Y00158S-040POY-040M-030ZTM-040SY-26M-0Y-0SY-0S
Giza 171	SAKHA 93 / GEMMEIZA 9	Gz2003-101-1GZ-4GZ-1GZ-2GZ-0S

Table 2: 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

Soil texture of the experimental site was clay and salty of pH nearly of 8.0. Soil samples were taken before sowing of crop 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 [61] and represented in Table 2.

The preceding summer crop in the both seasons was rice (*Oryza sativa,* L.). The experiment was laid out in a randomized complete block design (split-plot arrangement) with three replications. Wheat varieties were allocated in the main plots and the combinations between phosphorus and potassium fertilizer rates were arranged at random in sub-plots. The sub-plot area 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 varieties were sown 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.

Studied Parameters:

A) 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} in addition to harvest index % were estimated from the whole wheat plants in sub-plot.

B) 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 [62], crude protein content (%) was calculated by multiplying nitrogen content by 5.7 [63], phosphorus content (%) was determined colorimetrically according to the methods described in [62], Kernels potassium content (%) was assayed using a flame spectrophotometer (Corning 400, UK) using the standard method outlined by [64], fat content (%) was determined by using soxlet apparatus using petrolium ether as a solvent according to [65], crude fiber content (%) using the gravimetric method was done by [66], total carbohydrates content (%) in dry matter by using phenol-sulphuric acid method described by [67] as well as ash content (%) according to the methods described in [65, 68].

C) 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 50ºC 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°C 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.

C.1. Susceptibility of Wheat Grain (Non-Choice) Infestation: To study the susceptibility of wheat kernels obtained from kernels under 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:

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

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

C.2. Preferability Experiment (Free-Choice Infestation): In order to study preferability of wheat kernels by *Sitophilus oryzae*, three separate choice chamber (three replicates) of each tested treatment were made using glass jars (70 x 70 x 20 cm in height) covered with a lid. Number of Petri-dishes (6 cm diameter) was according to the number of treatments, each containing 20 g of tested wheat kernels was placed into prepared jars. Two hundred unsexed adults of newly emerged adults (0-2 days old) were released in each test chamber to give the insect a free-choice on any treatment. Number of insects harboured in each treatment after 5 days of releasing was used as an indicator for the preferability of tested cowpea seeds treatment for *S. oryzae*.

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^{-1}) = Grain yield X [(100 - Percent of damage)/100].

Germination (%): International Seed Testing Association [69] were applied, to conduct this test, sixty wheat grains were randomly collected from each treatment and kept in Petri dishes (9 cm diameter) lined with hair cotton and moistened with 4 ml of distilled water in three replicates, the Petri dishes (each Petri dish contains 20 seeds) containing wheat grains were left under laboratory conditions at Department of Stored Product Pests, Plant Protection Research Institute, Sakha Agricultural Research Station for seven days to let them germinate, then the germinated grains were visually counted on the basis of their appearance of radical, whereas percentage germination were calculated as given bellow:

Germination (%) = (No. of germinated grains/Total No. of grains) x 100.

Statistical Analysis: The analysis of variance was carried out according to the procedure described by [70]. Data were statistically analyzed according to using the MSTAT-C Statistical Software Package [71]. Where the F-test showed significant differences among means Turkey's Honestly Significance Difference (H.S.D.) test at 0.05 level was used to compare between means.

RESULTS AND DISCUSSION

A) Growth, Yield and its Components:

Performance of Wheat Varieties: Results presented in Tables 3, 4 and 5 show that all wheat growth, yield and yield components traits under study were differed significantly among the three wheat varieties (Misr 3, Sakha 95 and Giza 171) during 2019-20 and 2020-21 seasons. The differences between wheat varieties of Misr 3 and Sakha 95 did not reach the level of significance in days to maturity, No. of kernels $spike^{-1}$ in the both seasons, No. of spikelets $spike^{-1}$, 1000-kernel weight in the first season and spike length in the second season, also the differences between Misr 3 and Giza 171 on No. of spikelets $spike^{-1}$ in the first season and grain yield fed^{-1} in second season as well as the differences between Sakha 95 and Giza 171 on 1000-kernel weight in the first season were not significant. Misr 3 variety significantly produced the maximum mean values in No. of spikes m^{-2} (422.67 and 435.93), biological yield fed^{-1} (9067.41 and 9271.11 kg) and straw yield fed^{-1} (5605.56 and 5645.56 kg) as well as gave the shortest period from planting to heading (102.43 and 103.35 days) in the both seasons, respectively. Misr 3 variety increased straw yield fed^{-1} by 7.83 and 5.96 % in 2019-20 season, corresponding to 7.37 and 6.16 % in 2020-21 season, over straw yield fed^{-1} of Sakha 95 and Giza 171 varieties, respectively. The maximum mean values of plant height (118.02 and 122.78 cm), grain yield fed^{-1} (3667.78 and 3802.96 kg) and harvest index (41.32 and 41.91 %) as well as the longest period from planting to heading (105.19 and 106.37 days) and the shortest period from planting to maturity (146.26 and 148.80 days) were obtained from Sakha 95 variety in both seasons, respectively. Sakha 95 variety increased grain yield fed^{-1} by 5.95 and 7.58 % in the first season, corresponding to 4.89 and 6.36 % in the second season, over grain yield fed^{-1} of Misr 3 and Giza 171 varieties, respectively. Results may reveal the superiority of Giza 171 variety in spike length (11.78 and 12.28 cm), No. of spikelets $spike^{-1}$ (20.84 and 21.63), No. of kernels $spike^{-1}$ (68.22 and 69.24) and weight of 1000-kernel (52.77 and 53.78 g) as well as recorded the longest period from

Table 3: Mean values of heading date, maturity date, plant height and No. of spikes m^{-2} as affected by mean effect of wheat varieties, phosphorus fertilizer rates and potassium fertilizer rates during 2019-20 and 2020-21 seasons

Trait	Heading date		Maturity date		Plant height (cm)		No. of spikes m^{-2}	
Season	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Wheat varieties (V)								
Misr 3	102.43^{C}	103.35^{C}	146.43^{B}	148.93^{B}	98.52^{C}	102.72^{C}	422.67^{A}	435.93^{A}
Sakha 95	105.19^{A}	106.37^{A}	146.26^{B}	148.80^{B}	118.02^{A}	122.78^{A}	407.04^{B}	419.41^{B}
Giza 171	103.48^{B}	104.85^{B}	149.81^{A}	152.20^{A}	114.08^{B}	118.68^{B}	377.41^{C}	390.22^{C}
H.S.D. at 5 %	0.73	0.73	0.40	1.01	0.90	2.89	9.67	6.67
Phosphorus fertilizer rates kg P_2O_5 fed^{-1} (P)								
0	102.41^{C}	103.50^{C}	145.98^{C}	148.63^{C}	106.01^{C}	110.53^{C}	392.44^{C}	405.41^{C}
15	103.61^{B}	104.76^{B}	147.30^{B}	149.74^{B}	110.08^{B}	114.60^{B}	402.59^{B}	414.52^{B}
30	105.07^{A}	106.31^{A}	149.22^{A}	151.56^{A}	114.54^{A}	119.05^{A}	412.07^{A}	425.63^{A}
H.S.D. at 5 %	0.27	0.23	0.37	0.28	0.53	0.48	1.35	1.31
Potassium fertilizer rates kg K_2O fed^{-1} (K)								
0	102.83^{C}	104.26^{C}	146.57^{C}	149.04^{C}	106.89^{C}	111.64^{C}	398.07^{C}	411.41^{C}
24	103.80^{B}	104.94^{B}	147.67^{B}	150.09^{B}	110.65^{B}	115.13^{B}	403.11^{B}	415.70^{B}
48	104.46^{A}	105.37^{A}	148.26^{A}	150.80^{A}	113.09^{A}	117.41^{A}	405.93^{A}	418.44^{A}
H.S.D. at 5 %	0.27	0.23	0.37	0.28	0.53	0.48	1.35	1.31
F test V x P	**	**	**	**	**	**	**	**
Prob. V x K	N.S.	N.S.	N.S.	N.S.	**	**	**	**
P x K	**	**	**	**	**	**	**	**
V x P x K	N.S.	N.S.	N.S.	N.S.	**	**	**	**

Table 4: Mean values of spike length, No. of spikelets $spike^{-1}$, No. of kernels $spike^{-1}$ and 1000-kernel weight as affected by mean effect of wheat varieties, phosphorus fertilizer rates and potassium fertilizer rates during 2019-20 and 2020-21 seasons

Trait	Spike length (cm)		No. of spikelets $spike^{-1}$		No. of kernels $spike^{-1}$		1000-kernel weight (g)	
Season	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Wheat varieties (V)								
Misr 3	11.27^{B}	11.86^{B}	20.02^{AB}	20.19^{B}	55.56^{B}	58.09^{B}	51.73^{B}	52.44^{C}
Sakha 95	10.95^{C}	11.60^{B}	18.89^{B}	19.15^{C}	56.54^{B}	59.04^{B}	52.44^{AB}	53.17^{B}
Giza 171	11.78^{A}	12.28^{A}	20.84^{A}	21.63^{A}	68.22^{A}	69.24^{A}	52.77^{A}	53.78^{A}
H.S.D. at 5 %	0.12	0.30	1.21	0.56	2.94	2.16	0.70	0.35
Phosphorus fertilizer rates kg P_2O_5 fed^{-1} (P)								
0	11.06^{C}	11.66^{C}	19.39^{C}	19.87^{C}	57.70^{C}	59.71^{C}	51.34^{B}	52.07^{B}
15	11.38^{B}	11.94^{B}	19.92^{B}	20.36^{B}	60.06^{B}	62.31^{B}	52.50^{A}	53.33^{A}
30	11.56^{A}	12.14^{A}	20.44^{A}	20.73^{A}	62.56^{A}	64.34^{A}	53.09^{A}	54.00^{A}
H.S.D. at 5 %	0.04	0.04	0.12	0.10	0.29	0.40	0.19	0.11
Potassium fertilizer rates kg K_2O fed^{-1} (K)								
0	10.97^{C}	11.57^{C}	19.57^{C}	19.97^{C}	57.78^{C}	60.07^{C}	49.95^{C}	50.78^{C}
24	11.40^{B}	11.97^{B}	19.97^{B}	20.39^{B}	60.53^{B}	62.52^{B}	52.67^{B}	53.55^{B}
48	11.63^{A}	12.19^{A}	20.21^{A}	20.60^{A}	62.02^{A}	63.78^{A}	54.32^{A}	55.07^{A}
H.S.D. at 5 %	0.04	0.04	0.12	0.10	0.29	0.40	0.19	0.11
F test V x P	N.S.	N.S.	N.S.	N.S.	**	**	N.S.	N.S.
Prob. V x K	**	**	N.S.	N.S.	**	**	**	**
P x K	N.S.	N.S.	N.S.	N.S.	**	**	**	**
V x P x K	N.S.	N.S.	N.S.	N.S.	**	**	N.S.	N.S.

** Significant and N.S. No significant

planting to maturity (149.81 and 152.20 days) in the both seasons, respectively. Giza 171 variety increased No. of kernels $spike^{-1}$ by 22.79 and 20.66 % in 2019-20 season, corresponding to 19.19 and 17.28 % in 2020-21 season, over No. of kernels $spike^{-1}$ of Misr 3 and Sakha 95varieties, respectively. The differences among wheat traits were mainly due to the differences in the genetically constituents between wheat varieties under study (Misr 3, Sakha 95 and Giza 171). The increase in biological yield fed^{-1} of Misr 3 variety may be due to the increases in No. of spikes m^{-2} and straw yield fed^{-1}. It could be concluded that Sakha 95 surpassed the other two wheat varieties to increase grain yield fed^{-1} may be due to more likely attributed to the increase in harvest index. The results agree with those reported by [7, 8, 11, 12, 15, 16, 19, 20].

Table 5: Mean values of biological yield fed^{-1}, grain yield fed^{-1}, straw yield fed^{-1} and harvest index as affected by mean effect of wheat varieties, phosphorus fertilizer rates and potassium fertilizer rates during 2019-20 and 2020-21 seasons

Trait		Biological yield fed^{-1} (kg)		Grain yield fed^{-1} (kg)		Straw yield fed^{-1} (kg)		Harvest index (%)	
Season		2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Wheat varieties (V)									
Misr 3		9067.41^{A}	9271.11^{A}	3461.85^{B}	3625.56^{B}	5605.56^{A}	5645.56^{A}	38.13^{C}	39.05^{C}
Sakha 95		8866.30^{B}	9061.11^{B}	3667.78^{A}	3802.96^{A}	5198.52^{C}	5258.15^{C}	41.32^{A}	41.91^{A}
Giza 171		8699.63^{C}	8893.33^{C}	3409.26^{C}	3575.56^{B}	5290.37^{B}	5317.78^{B}	39.14^{B}	40.14^{B}
H.S.D. at 5 %		17.21	11.66	49.90	61.41	55.88	50.53	0.73	0.62
Phosphorus fertilizer rates kg P_2O_5 fed^{-1} (P)									
0		8429.26^{C}	8586.67^{C}	3253.70^{C}	3366.67^{C}	5175.56^{C}	5220.00^{C}	38.58^{C}	39.19^{C}
15		8910.37^{B}	9100.74^{B}	3515.93^{B}	3681.11^{B}	5394.44^{B}	5419.63^{B}	39.46^{B}	40.44^{B}
30		9293.70^{A}	9538.15^{A}	3769.26^{A}	3956.30^{A}	5524.44^{A}	5581.85^{A}	40.55^{A}	41.47^{A}
H.S.D. at 5 %		52.69	26.90	24.77	19.47	35.95	22.42	0.16	0.18
Potassium fertilizer rates kg K_2O fed^{-1} (K)									
0		8651.11^{C}	8840.37^{C}	3322.22^{C}	3464.07^{C}	5328.89^{B}	5376.30^{C}	38.37^{C}	39.15^{C}
24		8927.41^{B}	9112.96^{B}	3546.67^{B}	3703.33^{B}	5380.74^{A}	5409.63^{B}	39.71^{B}	40.60^{B}
48		9054.81^{A}	9272.22^{A}	3670.00^{A}	3836.67^{A}	5384.81^{A}	5435.56^{A}	40.51^{A}	41.35^{A}
H.S.D. at 5 %		52.69	26.90	24.77	19.47	35.95	22.42	0.16	0.18
F test	V x P	**	**	**	**	**	**	**	**
Prob.	V x K	**	**	**	**	N.S.	N.S.	**	**
	P x K	**	**	**	**	**	**	**	**
	V x P x K	**	**	**	**	N.S.	N.S.	**	**

** Significant and N.S. No significant

Effect of Phosphorus Fertilizer Rates: Results in Tables 3, 4 and 5 indicated that increasing phosphorus fertilizer rates from 0 to 15 and 30 kg P_2O_5 fed^{-1} caused significant increments in mean values of all growth, yield and yield components of wheat under study during 2019-20 and 2020-21 seasons. The differences between phosphorus fertilization rates of 15 and 30 kg P_2O_5 fed^{-1} on mean values of 1000-kernel weight in the both seasons was not significant. Wheat plants treated with 30 kg P_2O_5 fed^{-1} gave significantly the maximum mean values of plant height (114.54 and 119.05 cm), No. of spikes m^{-2} (412.07 and 425.63), spike length (11.56 and 12.14 cm), No. of spikelets spike^{-1} (20.44 and 20.73), No. of kernels spike^{-1} (62.56 and 64.34), 1000-kernel weight (53.09 and 54.00 g), biological yield fed^{-1} (9293.70 and 9538.15 kg), grain yield fed^{-1} (3769.26 and 3956.30 kg), straw yield fed^{-1} (5524.44 and 5581.85 kg) and harvest index (40.55 and 41.47 %) as well as recorded significantly the longest period from planting to heading (105.07 and 106.31 days) and maturity (149.22 and 151.56 days) in the both seasons, respectively. The superiority ratios in the first season between 30 kg P_2O_5 fed^{-1} and each of 0 and 15 kg P_2O_5 fed^{-1} were 10.26 and 4.30 % for biological yield fed^{-1} in addition to 15.85 and 7.21 % for grain yield fed^{-1}, respectively. The increases ratios in the second season when wheat treated with 30 kg P_2O_5 fed^{-1} over each of 0 and 15 kg P_2O_5 fed^{-1} were 11.08 and 4.81 % for biological yield fed^{-1} in addition 17.51 and 7.48 % for grain yield fed^{-1}, respectively. Such results stated the vital role of phosphorus fertilization in improving the productivity of wheat. The superiority of phosphorus application as 30 kg P_2O_5 fed^{-1} on seed yield fed^{-1} may be due to its good effect on kernels filling period, plant height, No. of spikes m^{-2}, spike length, No. of spikelets spike^{-1}, No. of kernels spike^{-1}, 1000-kernel weight, biological yield fed^{-1} and harvest index during the both seasons. These results are in harmony with those obtained by [12, 15, 19, 20, 23, 24, 29, 30, 33, 34, 35]

Effect of Potassium Fertilizer Rates: Results in Tables 3, 4 and 5 showed that growth, yield and its attributes of wheat, *i.e.* days to heading, days to maturity, plant height, No. of spikes m^{-2}, spike length, No. of spikelets spike^{-1}, No. of kernels spike^{-1}, 1000-kernel weight, biological yield fed^{-1}, grain yield fed^{-1}, straw yield fed^{-1} and harvest index were significantly increased by increasing potassium fertilizer rates from 0 and 24 to 48 kg K_2O fed^{-1}, but, the differences between potassium fertilizer rates of 24 and 48 kg K_2O fed^{-1} on mean values of straw yield fed^{-1} in the second season was not significant. In general, the higher potassium rate (48 kg K_2O fed^{-1}) was more effective in increasing mean values of all studied traits and recorded the longest period from planting to heading (104.46 and 105.37 days) and maturity (148.26 and 150.80 days) as well as gave highest mean values of plant height (113.09 and 117.41 cm), No. of spikes m^{-2}(405.93

Table 6: Mean values of agronomic traits of wheat as affected by the interaction between wheat varieties and phosphorus fertilizer rates 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
Variety	P rate kg P_2O_5 fed^{-1}	Days to heading		Days to maturity		Plant height (cm)		No. of spikes m^{-2}		No. of kernels spike^{-1}	
Misr 3	0	101.17^{F}	101.94^{G}	144.89^{E}	147.50^{E}	94.20^{G}	99.25^{G}	412.44^{C}	424.89^{C}	53.22^{I}	55.94^{G}
	15	102.56^{E}	103.56^{F}	146.5^{ED}	148.94^{D}	98.78^{F}	102.81^{F}	423.33^{B}	436.44^{B}	55.46^{G}	58.26^{F}
	30	103.56^{CD}	104.56^{E}	147.89^{C}	150.33^{C}	102.59^{E}	106.11^{E}	432.22^{A}	446.44^{A}	58.01^{E}	60.06^{E}
Sakha 95	0	104.06^{C}	105.39^{D}	144.83^{E}	147.56^{E}	113.76^{C}	118.19^{C}	398.22^{E}	411.33^{E}	54.30^{H}	56.79^{G}
	15	105.06^{B}	106.00^{C}	146.11^{D}	148.44^{D}	118.01^{B}	122.60^{B}	407.56^{D}	419.33^{D}	56.43^{F}	59.20^{EF}
	30	106.44^{A}	107.72^{A}	147.83^{C}	150.39^{C}	122.30^{A}	127.54^{A}	415.33^{C}	427.56^{C}	58.89^{D}	61.13^{D}
Giza 171	0	102.00^{E}	103.17^{F}	148.22^{C}	150.83^{C}	110.07^{D}	114.15^{D}	366.67^{H}	380.00^{H}	65.58^{C}	66.41^{C}
	15	103.22^{D}	104.72^{E}	149.28^{B}	151.83^{B}	113.45^{C}	118.39^{C}	376.89^{G}	387.78^{G}	68.30^{B}	69.48^{B}
	30	105.22^{B}	106.67^{B}	151.94^{A}	153.94^{A}	118.73^{B}	123.49^{B}	388.67^{F}	402.89^{F}	70.77^{A}	71.82^{A}
H.S.D. at 5 %		0.62	0.54	0.85	0.65	1.23	1.10	3.14	3.06	0.67	0.93

Variety	P rate kg P_2O_5 fed^{-1}	Biological yield fed^{-1} (kg)		Grain yield fed^{-1} (kg)		Straw yield fed^{-1} (kg)		Harvest index (%)	
Misr 3	0	8616.67^{E}	8785.56^{F}	3212.22^{E}	3336.67^{F}	5404.44^{CD}	5448.89^{CD}	37.25^{F}	37.95^{G}
	15	9100.00^{C}	9295.56^{C}	3466.67^{C}	3635.56^{D}	5633.33^{B}	5660.00^{B}	38.08^{E}	39.10^{F}
	30	9485.56^{A}	9732.22^{A}	3706.67^{B}	3904.44^{B}	5778.89^{A}	5827.78^{A}	39.06^{D}	40.10^{E}
Sakha 95	0	8421.11^{F}	8571.11^{G}	3394.44^{D}	3500.00^{E}	5026.67^{F}	5071.11^{G}	40.28^{C}	40.80^{D}
	15	8896.67^{D}	9086.67^{D}	3673.33^{B}	3813.33^{C}	5223.33^{E}	5273.33^{E}	41.28^{B}	41.95^{B}
	30	9281.11^{B}	9525.56^{B}	3935.56^{A}	4095.56^{A}	5345.56^{D}	5430.00^{D}	42.39^{A}	42.98^{A}
Giza 171	0	8250.00^{G}	8403.33^{H}	3154.44^{E}	3263.33^{G}	5095.56^{F}	5140.00^{F}	38.21^{E}	38.81^{F}
	15	8734.44^{E}	8920.00^{E}	3407.78^{D}	3594.44^{D}	5326.67^{D}	5325.56^{E}	39.00^{D}	40.28^{E}
	30	9114.44^{C}	9356.67^{C}	3665.56^{B}	3868.89^{B}	5448.89^{C}	5487.78^{C}	40.20^{C}	41.34^{C}
H.S.D. at 5 %		122.55	62.55	57.60	45.29	83.61	52.13	0.38	0.42

and 418.44), spike length (11.63 and 12.19 cm), No. of spikelets spike^{-1} (20.21 and 20.60), No. of kernels spike^{-1} (62.02 and 63.78), 1000-kernel weight (54.32 and 55.07 g), biological yield fed^{-1} (9054.81 and 9272.22 kg), grain yield fed^{-1} (3670.00 and 3836.67 kg), straw yield fed^{-1} (5384.81 and 5435.56 kg) and harvest index (40.51 and 41.35 %) in the first and second seasons, respectively. The superiority ratios in the first season when received 48 kg K_2O fed^{-1} over each of 0 and 24 kg K_2O fed^{-1} were 4.67 and 1.43 % for biological yield fed^{-1} in addition to 10.47 and 3.48 % for grain yield fed^{-1}, respectively. The increases ratios in the second season when wheat treated with 48 kg K_2O fed^{-1} over each of 0 and 24 kg K_2O fed^{-1} were 4.88 and 1.75 % for biological yield fed^{-1} in addition to 10.76 and 3.60 % for grain yield fed^{-1}, respectively. The increase in wheat traits associated with increasing potassium fertilization rates may be attributed to the role of potassium in many physiological processes, *i.e.* water relations, photosynthesis, assimilate transport, protein synthesis and enzyme activation can have direct consequences on wheat productivity. These results are in compatible with those found by [6, 7, 24, 27, 36, 38, 39, 40, 41, 42, 43, 44, 45, 46].

Effect of the Interaction Between Wheat Varieties and Phosphorus Fertilizer Rates: Results in Tables 3, 4 and 5 indicated that significant effect of the interaction between wheat varieties (Misr 3, Sakha 95 and Giza 171) and phosphorus fertilizer rates (0, 15 and 30 kg P_2O_5 fed^{-1}) obtained for almost wheat traits under study except, mean values of spike length, No. of spikelets spike^{-1} and 1000-kernel weight were not significantly affected by the interaction in the both seasons. Data in Table 6 recorded that Misr 3 variety treated with 30 kg P_2O_5 fed^{-1} recorded the greatest mean values in No. of spikes m^{-2} (432.22 and 446.44), biological yield fed^{-1} (9485.56 and 9732.22 kg) and straw yield fed^{-1} (5778.89 and 5827.78 kg) during the both seasons, respectively. The longest period from planting to heading (106.44 and 107.72 days) and the highest mean values of plant height (122.30 and 127.54 cm), grain yield fed^{-1} (3935.56 and 4095.56 kg) and harvest index (42.39 and 42.98 %) which were obtained from Sakha 95 variety when received 30 kg P_2O_5 fed^{-1}. Meanwhile, Giza 171 variety when received 30 kg P_2O_5 fed^{-1} gave the longest period from planting to maturity (151.94 and 153.94 days) as well as produced the greatest mean values in No. of kernels spike^{-1} (70.77 and 71.82) in both seasons, respectively. Similar results were also reported by [1, 5, 9, 10, 12, 14, 15, 17, 19 and 20] whose found variations in mean values of wheat yield and related traits between wheat varieties and phosphorus fertilizer rates interaction.

Table 7: Mean values of agronomic traits of wheat as affected by the interaction between wheat varieties and potassium fertilizer rates during 2019-20 and 2020-21 seasons

Season		2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Variety	K rate kg K_2O fed^{-1}	Plant height (cm)		No. of spikes m^{-2}		Spike length (cm)		No. of kernels spike^{-1}	
Misr 3	0	94.77^{H}	99.83^{H}	418.44^{B}	432.22^{B}	10.88^{G}	11.49^{F}	53.23^{H}	56.05^{H}
	24	98.89^{G}	103.01^{G}	423.33^{A}	436.67^{A}	11.36^{D}	11.93^{D}	55.95^{F}	58.49^{F}
	48	101.90^{F}	105.33^{F}	426.22^{A}	438.89^{A}	11.57^{C}	12.16^{C}	57.51^{E}	59.71^{DE}
Sakha 95	0	114.88^{D}	119.39^{D}	403.33^{D}	416.00^{D}	10.62^{H}	11.29^{G}	54.26^{G}	57.12^{G}
	24	118.55^{B}	123.38^{B}	407.33^{C}	419.78^{C}	10.99^{F}	11.63^{E}	56.95^{E}	59.42^{EF}
	48	120.64^{A}	125.55^{A}	410.44^{C}	422.44^{C}	11.23^{E}	11.87^{D}	58.41^{D}	60.58^{D}
Giza 171	0	111.01^{E}	115.70^{E}	372.44^{F}	386.00^{G}	11.40^{D}	11.94^{D}	65.83^{C}	67.02^{C}
	24	114.51^{D}	118.99^{D}	378.67^{E}	390.67^{F}	11.84^{B}	12.35^{B}	68.68^{B}	69.64^{B}
	48	116.73^{C}	121.35^{C}	381.11^{E}	394.00^{E}	12.10^{A}	12.54^{A}	70.14^{A}	71.05^{A}
H.S.D. at 5 %		1.23	1.10	3.14	3.06	0.09	0.09	0.67	0.93
Variety	K rate kg K_2O fed^{-1}	1000-kernel weight (g)		Biological yield fed^{-1} (kg)		Grain yield fed^{-1} (kg)		Harvest index (%)	
Misr 3	0	49.22^{G}	50.02^{H}	8832.22^{CD}	9033.33^{D}	3270.00^{F}	3424.44^{G}	36.99^{F}	37.88^{G}
	24	52.01^{D}	52.82^{E}	9121.11^{B}	9310.00^{B}	3488.89^{E}	3656.67^{E}	38.23^{E}	39.23^{F}
	48	53.96^{B}	54.48^{C}	9248.89^{A}	9470.00^{A}	3626.67^{C}	3795.56^{C}	39.18^{D}	40.04^{E}
Sakha 95	0	50.07^{F}	50.89^{G}	8644.44^{E}	8826.67^{F}	3467.78^{E}	3584.44^{F}	40.07^{C}	40.56^{D}
	24	52.79^{C}	53.57^{D}	8912.22^{C}	9097.78^{C}	3707.78^{B}	3844.44^{B}	41.57^{B}	42.22^{B}
	48	54.45^{A}	55.06^{B}	9042.22^{B}	9258.89^{B}	3827.78^{A}	3980.00^{A}	42.31^{A}	42.95^{A}
Giza 171	0	50.56^{E}	51.44^{F}	8476.67^{F}	8661.11^{G}	3228.89^{F}	3383.33^{G}	38.05^{E}	39.01^{F}
	24	53.22^{C}	54.25^{C}	8748.89^{DE}	8931.11^{E}	3443.33^{E}	3608.89^{F}	39.32^{D}	40.36^{CD}
	48	54.53^{A}	55.65^{A}	8873.33^{C}	9087.78^{CD}	3555.56^{D}	3734.44^{D}	40.04^{C}	41.06^{C}
H.S.D. at 5 %		0.45	0.27	122.55	62.55	57.60	45.29	0.38	0.42

Effect of the Interaction Between Wheat Varieties and Potassium Fertilizer Rates: Significant effect of the interaction between wheat varieties and potassium fertilizer rates obtained for almost growth, yield components and wheat yield during 2019-20 and 2020-21 seasons were significant except, days to heading, days to maturity, No. of spikelets spike^{-1} and straw yield fed^{-1} (Tables 3, 4 and 5). Data in Table 7 showed that Misr 3 variety treat with 30 kg K_2O fed^{-1} recorded the greatest mean values in No. of spikes m^{-2} (426.22 and 438.89) and biological yield fed^{-1} (9248.89 and 9470.00 kg) during the two seasons, respectively. While, Sakha 95 variety when received 30 kg K_2O fed^{-1} produced the maximum mean values of plant height (120.64 and 125.55 cm), grain yield fed^{-1} (3827.78 and 3980.00 kg) and harvest index (42.31 and 42.95 %) during the two seasons, respectively. Whereas, Giza 171 variety under soil fertilized by 30 kg K_2O fed^{-1} gave the highest mean values of spike length (12.10 and 12.54 cm), No. of kernels spike^{-1} (70.14 and 71.05) and 1000-kernel weight (54.53 and 55.65 g) in the first and second seasons, respectively. The results agree with those reported by [2, 3, 6, 7, 18] whose concluded that mean values of seed and oil yield and its related traits were significantly affected by the interaction of wheat varieties and potassium fertilizer rates.

Effect of the Interaction Between Phosphorus and Potassium Fertilizer Rates: Results in Tables 3, 4 and 5 showed that significant effect of the interaction between phosphorus fertilizer rates (0, 15 and 30 kg P_2O_5 fed^{-1}) and potassium fertilizer rates (0, 24 and 48 kg K_2O fed^{-1}) obtained for almost growth, yield and yield components of wheat in the both seasons. While, mean values of spike length and No. of spikelets spike^{-1} were not significantly affected by the interaction between phosphorus and potassium fertilizer rates in both seasons. Data in Table 8, showed that the maximum mean values of plant height (117.51 and 121.93 cm), No. of spikes m^{-2} (416.22 and 429.78), No. of kernels spike^{-1} (64.45 and 65.62), weight of 1000-kernel (54.87 and 55.67 g), biological yield fed^{-1} (9444.44 and 9706.67 kg), grain yield fed^{-1} (3928.89 and 4120.00 kg), straw yield fed^{-1} (5515.56 and 5586.67 kg) and harvest index (41.60 and 42.45 %) in addition to the longest period from planting to heading (105.78 and 106.67 days) and maturity (150.06 and 152.39 days) in the both seasons, respectively were recorded from wheat plants when received 30 kg P_2O_5 and 48 kg K_2O fed^{-1}. On the other hand, growing wheat under without phosphorus and potassium fertilizers application significantly recorded the minimum mean values in plant height (102.40 and 107.42 cm), No. of spikes m^{-2} (387.56 and 402.00), No.

Table 8: Mean values of agronomic traits of wheat as affected by the interaction between phosphorus and potassium fertilizer rates 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
P rate kg P_2O_5 fed^{-1}	K rate kg K_2O fed^{-1}	Days to heading		Days to maturity		Plant height (cm)		No. of spikes m^{-2}		No. of kernels spike^{-1}	
0	0	101.44^{F}	102.50^{E}	144.94^{E}	147.61^{G}	102.40^{G}	107.42^{G}	387.56^{G}	402.00^{F}	55.01^{F}	56.98^{E}
	24	102.44^{E}	103.67^{E}	146.22^{D}	148.67^{F}	106.47^{F}	110.95^{F}	393.33^{F}	405.78^{E}	58.09^{E}	60.21^{D}
	48	103.33^{CD}	104.33^{D}	146.78^{CD}	149.61^{E}	109.17^{E}	113.23^{E}	396.44^{EF}	408.44^{E}	60.00^{D}	61.96^{C}
15	0	102.83^{DE}	104.33^{D}	146.44^{D}	148.94^{F}	107.24^{F}	111.92^{F}	399.56^{E}	412.00^{D}	58.03^{E}	60.56^{D}
	24	103.72^{BC}	104.83^{C}	147.50^{BC}	149.89^{DE}	110.40^{DE}	114.82^{D}	403.11^{D}	414.44^{CD}	60.55^{D}	62.61^{C}
	48	104.28^{B}	105.11^{C}	147.94^{B}	150.39^{CD}	112.59^{C}	117.07^{C}	405.11^{CD}	417.11^{C}	61.62^{C}	63.77^{B}
30	0	104.22^{B}	105.94^{B}	148.33^{B}	150.56^{C}	111.03^{D}	115.59^{D}	407.11^{C}	420.22^{B}	60.29^{D}	62.66^{C}
	24	105.22^{A}	106.33^{AB}	149.28^{A}	151.72^{B}	115.07^{B}	119.61^{B}	412.89^{B}	426.89^{A}	62.94^{B}	64.73^{A}
	48	105.78^{A}	106.67^{A}	150.06^{A}	152.39^{A}	117.51^{A}	121.93^{A}	416.22^{A}	429.78^{A}	64.45^{A}	65.62^{A}
H.S.D. at 5 %		0.62	0.54	0.85	0.65	1.23	1.10	3.14	3.06	0.67	0.93
P rate kg P_2O_5 fed^{-1}	K rate kg K_2O fed^{-1}	1000-kernel weight (g)		Biological yield fed^{-1} (kg)		Grain yield fed^{-1} (kg)		Straw yield fed^{-1} (kg)		Harvest index (%)	
0	0	48.73^{G}	49.47^{H}	8141.11^{F}	8321.11^{G}	3025.56^{H}	3142.22^{H}	5115.56^{D}	5178.89^{E}	37.17^{F}	37.77^{F}
	24	51.73^{D}	52.41^{E}	8498.89^{E}	8603.33^{F}	3304.44^{G}	3392.22^{G}	5194.44^{CD}	5211.11^{E}	38.89^{E}	39.44^{E}
	48	53.57^{B}	54.32^{C}	8647.78^{D}	8835.56^{E}	3431.11^{E}	3565.56^{E}	5216.67^{C}	5270.00^{D}	39.68^{D}	40.36^{D}
15	0	50.05^{F}	50.94^{G}	8711.11^{D}	8876.67^{E}	3364.44^{F}	3505.56^{F}	5346.67^{B}	5371.11^{C}	38.63^{E}	39.50^{E}
	24	52.94^{C}	53.85^{D}	8947.78^{C}	9151.11^{D}	3533.33^{D}	3713.33^{D}	5414.44^{B}	5437.78^{B}	39.50^{D}	40.59^{D}
	48	54.51^{A}	55.20^{B}	9072.22^{B}	9274.44^{C}	3650.00^{C}	3824.44^{C}	5422.22^{B}	5450.00^{B}	40.24^{C}	41.25^{C}
30	0	51.06^{E}	51.94^{F}	9101.11^{B}	9323.33^{C}	3576.67^{D}	3744.44^{D}	5524.44^{A}	5578.89^{A}	39.31^{D}	40.18^{D}
	24	53.35^{BC}	54.39^{C}	9335.56^{A}	9584.44^{B}	3802.22^{B}	4004.44^{B}	5533.33^{A}	5580.00^{A}	40.74^{B}	41.79^{B}
	48	54.87^{A}	55.67^{A}	9444.44^{A}	9706.67^{A}	3928.89^{A}	4120.00^{A}	5515.56^{A}	5586.67^{A}	41.60^{A}	42.45^{A}
H.S.D. at 5 %		0.45	0.27	122.55	62.55	57.60	45.29	83.61	52.13	0.38	0.42

of kernels spike^{-1} (55.01 and 56.98), 1000-kernel weight (48.73 and 49.47 g), biological yield fed^{-1} (8141.11 and 8321.11 kg), grain yield fed^{-1} (3025.56 and 3142.22 kg), straw yield fed^{-1} (5115.56 and 5178.89 kg) and harvest index (37.17 and 37.77 %) in addition to the shortest period from planting to heading (101.44 and 102.50 days) and maturity (144.94 and 147.61 days) in the both seasons, respectively. Such results are in accordance with those obtained by [21, 24, 27, 28, 32], which reported that mean values of wheat growth, yield and its components were significantly differences by the interaction between phosphorus and potassium fertilizer rates.

Effect of the Interaction among Wheat Varieties, Phosphorus and Potassium Fertilizer Rates: Results in Tables 3, 4 and 5 showed significant the interaction effect among wheat varieties (Misr 3, Sakha 95 and Giza 171), phosphorus fertilizer rates (0, 15 and 30 kg P_2O_5 fed^{-1}) and potassium fertilizer rates (0, 24 and 48 kg K_2O fed^{-1}) on mean values of plant height, No. of spikes m^{-2}, No. of kernels spike^{-1}, biological yield fed^{-1}, grain yield fed^{-1} and harvest index of wheat. While, mean values of days to heading, days to maturity, spike length, No. of spikelets spike^{-1}, 1000-kernel weight and straw yield fed^{-1} were not significantly affected by the interaction in the both seasons. Data in Table 9 recorded that the highest mean values in No. of spikes m^{-2} (436.00 and 450.00) and biological yield fed^{-1} (9630.00 and 9900.00 kg) in the both seasons, respectively which were obtained from Misr 3 variety under soil fertilized by 30 kg P_2O_5 and 48 kg K_2O fed^{-1}. Planting wheat variety of Sakha 95 when received 30 kg P_2O_5 and 48 kg K_2O fed^{-1} gave the maximum mean values of plant height (125.32 and 130.99 cm), grain yield fed^{-1} (4083.33 and 4266.67 kg) and harvest index (43.27 and 44.00 %) during the both seasons, respectively. Giza 171 variety treated with 30 kg P_2O_5 and 48 kg K_2O fed^{-1} gave the greatest mean values in No. of kernels spike^{-1} (72.53 and 73.38) in the both seasons, respectively. Such results are in accordance with those obtained by [13].

B) Kernels Chemical Properties:

Performance of Wheat Varieties: Results presented in Tables 10 and 11, show that all kernels chemical properties of wheat under study were differed significantly among the three wheat varieties, *i.e.* Misr 3, Sakha 95 and Giza 171 during 2019-20 and 2020-21 seasons. The differences between wheat varieties of Misr 3 and Sakha 95 did not reach the level of significance in kernel potassium content and kernel crude fiber content in the both seasons as well as kernel phosphorus content in the second season, also the differences between Misr 3 and Giza 171 on kernel phosphorus content and kernel ash content in the second

Table 9: Mean values of plant height, No. of spikes m^{-2}, No. of kernels $spike^{-1}$, biological yield fed^{-1}, grain yield fed^{-1} and harvest index of wheat as affected by the interaction among wheat varieties, phosphorus and phosphorus fertilizer rates during 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
Variety	P rate kg P_2O_5 fed^{-1}	K rate kg K_2O fed^{-1}	Plant height (cm)		No. of spikes m^{-2}		No. of kernels $spike^{-1}$		Biological yield fed^{-1} (kg)		Grain yield fed^{-1} (kg)		Harvest index (%)	
Misr 3	0	0	88.48^{N}	95.22^{O}	407.33^{GHI}	422.67^{FGHI}	50.77^{R}	53.16^{Q}	8326.67^{KL}	8516.67^{PQ}	2993.33^{O}	3140.00^{Q}	35.95^{P}	36.87^{O}
		24	94.92^{M}	99.78^{N}	413.33^{EFG}	424.67^{FGH}	53.36^{PQ}	56.63^{OP}	8683.33^{GHIJ}	8800.00^{MN}	3256.67^{MN}	3346.67^{NO}	37.50^{MNO}	38.02^{MN}
		48	99.21^{L}	102.75^{LM}	416.67^{EF}	427.33^{EFG}	55.54^{MNO}	58.02^{L-P}	8840.00^{FGH}	9040.00^{JK}	3386.67^{JKL}	3523.33^{L}	38.31^{JKLM}	38.97^{KL}
	15	0	96.02^{M}	100.52^{MN}	420.00^{DE}	432.00^{DE}	53.28^{Q}	56.49^{P}	8866.67^{FGH}	9066.67^{JK}	3313.33^{KLM}	3466.67^{LM}	37.37^{NO}	38.23^{LMN}
		24	98.84^{L}	102.77^{LM}	424.00^{CD}	438.00^{CD}	56.09^{LMN}	58.50^{K-O}	9156.67^{CDE}	9350.00^{FGH}	3486.67^{HIJ}	3663.33^{IJ}	38.08^{LMN}	39.18^{IJK}
		48	101.47^{KL}	105.15^{IK}	426.00^{BCD}	439.33^{C}	57.00^{JKL}	59.79^{H-L}	9276.67^{BCD}	9470.00^{DEF}	3600.00^{FGH}	3776.67^{GH}	38.81^{IJKL}	39.88^{HIJ}
	30	0	99.81^{L}	103.75^{KL}	428.00^{BC}	442.00^{BC}	55.64^{LMNO}	58.50^{K-O}	9303.33^{BCD}	9516.67^{DE}	3503.33^{HIJ}	3666.67^{IJ}	37.65^{MNO}	38.53^{KLM}
		24	102.91^{JK}	106.49^{IJ}	432.67^{AB}	447.33^{AB}	58.41^{IJ}	60.35^{G-K}	9523.33^{AB}	9780.00^{AB}	3723.33^{DEF}	3960.00^{DE}	39.10^{HIJ}	40.49^{GH}
		48	105.03^{IJ}	108.08^{I}	436.00^{A}	450.00^{A}	59.98^{GH}	61.31^{GHI}	9630.00^{A}	9900.00^{A}	3893.33^{BC}	4086.67^{BC}	40.43^{EFG}	41.28^{DEFG}
Sakha 95	0	0	111.48^{FGH}	115.57^{G}	394.00^{KL}	407.33^{LM}	51.74^{R}	54.14^{Q}	8133.33^{LM}	8306.67^{R}	3150.00^{N}	3243.33^{P}	38.73^{IJKL}	39.05^{JKL}
		24	113.90^{DEF}	118.66^{EF}	398.67^{JK}	412.00^{KL}	54.74^{NOP}	57.28^{NOP}	8490.00^{JK}	8586.67^{OP}	3453.33^{IJ}	3540.00^{KL}	40.68^{DEF}	41.23^{EFG}
		48	115.91^{D}	120.35^{E}	402.00^{IJ}	414.67^{JK}	56.42^{LM}	58.95^{J-N}	8640.00^{HIJ}	8820.00^{MN}	3580.00^{GH}	3716.67^{HIJ}	41.44^{CD}	42.14^{CD}
	15	0	114.59^{DE}	119.22^{E}	405.33^{HIJ}	417.33^{IJK}	54.38^{OPQ}	57.57^{M-P}	8716.67^{GHIJ}	8863.33^{LM}	3510.00^{HIJ}	3636.67^{JK}	40.27^{FG}	41.03^{FG}
		24	118.75^{C}	123.24^{D}	407.33^{GHI}	419.33^{HIJ}	56.92^{KLM}	59.40^{I-M}	8923.33^{EFG}	9136.67^{IJ}	3690.00^{EFG}	3846.67^{FG}	41.35^{D}	42.10^{CDE}
		48	120.68^{BC}	125.33^{CD}	410.00^{FGH}	421.33^{GHI}	58.00IJK	60.63^{G-J}	9050.00^{DEF}	9260.00^{HI}	3820.00^{CD}	3956.67^{DE}	42.21^{BC}	42.73^{BC}
	30	0	118.58^{C}	123.37^{D}	410.67^{FGH}	423.33^{FI}	56.66^{KLM}	59.65^{H-L}	9083.33^{CDEF}	9310.00^{HJ}	3743.33^{DE}	3873.33^{EFG}	41.21^{DE}	41.60^{DEF}
		24	122.99^{AB}	128.25^{B}	416.00^{EF}	428.00^{EF}	59.20^{HI}	61.58^{GH}	9323.33^{BC}	9570.00^{CD}	3980.00^{AB}	4146.67^{B}	42.69^{AB}	43.33^{AB}
		48	125.32^{A}	130.99^{A}	419.33^{DE}	431.33^{E}	60.82^{G}	62.16^{FG}	9436.67^{AB}	9696.67^{BC}	4083.33^{A}	4266.67^{A}	43.27^{A}	44.00^{A}
Giza 171	0	0	107.23^{I}	111.46^{H}	361.33^{P}	376.00^{Q}	62.52^{F}	63.62^{F}	7963.33^{M}	8140.00^{S}	2933.33^{O}	3043.33^{Q}	36.83^{O}	37.39^{NO}
		24	110.59^{H}	114.41^{G}	368.00^{OP}	380.67^{PQ}	66.19^{E}	66.72^{E}	8323.33^{KL}	8423.33^{QR}	3203.33^{MN}	3290.00^{OP}	38.49^{IJKL}	39.06^{JKL}
		48	112.39^{EFGH}	116.59^{FG}	370.67^{O}	383.33^{P}	68.04^{D}	68.90^{CD}	8463.33^{JK}	8646.67^{OP}	3326.67^{KLM}	3456.67^{LM}	39.31^{HI}	39.98^{HI}
	15	0	111.10^{GH}	116.00^{G}	373.33^{NO}	386.67^{OP}	66.41^{E}	67.62^{DE}	8550.00^{IJK}	8700.00^{NO}	3270.00^{LMN}	3413.33^{MN}	38.24^{KLM}	39.23^{IJK}
		24	113.62^{DEFG}	118.46^{EF}	378.00^{MN}	386.00^{OP}	68.63^{CD}	69.93^{C}	8763.33^{GHI}	8966.67^{KL}	3423.33^{IJK}	3630.00^{JK}	39.06^{HIJK}	40.48^{GH}
		48	115.63^{D}	120.72^{E}	379.33^{MN}	390.67^{NO}	69.85^{BC}	70.89^{BC}	8890.00^{FGH}	9093.33^{JK}	3530.00^{HI}	3740.00^{HI}	39.71^{GH}	41.13^{FG}
	30	0	114.70^{DE}	119.65^{E}	382.67^{M}	395.33^{N}	68.57^{CD}	69.83^{C}	8916.67^{EFG}	9143.33^{IJ}	3483.33^{HIJ}	3693.33^{HIJ}	39.06^{HIJK}	40.40^{GH}
		24	119.32^{C}	124.09^{D}	390.00^{L}	405.33^{M}	71.21^{AB}	72.26^{AB}	9160.00^{CDE}	9403.33^{EFG}	3703.33^{DEFG}	3906.67^{EF}	40.42^{EFG}	41.55^{DEF}
		48	122.19^{B}	126.73^{BE}	393.33^{KL}	408.00^{LM}	72.53^{A}	73.38^{A}	9266.67^{BCD}	9523.33^{DE}	3810.00^{CDE}	4006.67^{CD}	41.11^{DE}	42.07^{CDE}
H.S.D. at 5 %			2.75	2.46	7.00	6.81	1.49	2.08	273.19	139.44	128.40	100.95	0.85	0.94

Table 10: Mean values of nitrogen content, crude protein content, phosphorus content and potassium content in kernels as affected by mean effect of wheat varieties, phosphorus fertilizer rates and potassium fertilizer rates during 2019-20 and 2020-21 seasons

Trait		N content (%)		Crude protein content (%)		P content (%)		K content (%)	
Season		2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Wheat varieties (V)									
Misr 3		2.666^{A}	2.615^{A}	15.19^{A}	14.91^{A}	0.494^{B}	0.504^{AB}	0.519^{AB}	0.529^{AB}
Sakha 95		2.311^{C}	2.272^{C}	13.17^{C}	12.95^{C}	0.536^{A}	0.544^{A}	0.556^{A}	0.564^{A}
Giza 171		2.498^{B}	2.460^{B}	14.24^{B}	14.02^{B}	0.457^{C}	0.466^{B}	0.486^{B}	0.495^{B}
H.S.D. at 5 %		0.119	0.137	0.28	0.33	0.031	0.043	0.043	0.053
Phosphorus fertilizer rates kg P_2O_5 fed^{-1} (P)									
0		2.453^{B}	2.407^{B}	13.98^{C}	13.72^{C}	0.464^{B}	0.472^{B}	0.511	0.520
15		2.493^{AB}	2.446^{AB}	14.21^{B}	13.94^{B}	0.500^{A}	0.507^{AB}	0.522	0.530
30		2.528^{A}	2.494^{A}	14.41^{A}	14.22^{A}	0.524^{A}	0.534^{A}	0.529	0.536
H.S.D. at 5 %		0.066	0.083	0.16	0.20	0.029	0.036	N.S.	N.S.
Potassium fertilizer rates kg K_2O fed^{-1} (K)									
0		2.365^{C}	2.303^{C}	13.48^{C}	13.13^{C}	0.487	0.496	0.489^{C}	0.497^{B}
24		2.507^{B}	2.468^{B}	14.29^{B}	14.07^{B}	0.497	0.505	0.524^{B}	0.531^{A}
48		2.602^{A}	2.576^{A}	14.83^{A}	14.68^{A}	0.504	0.512	0.548^{A}	0.559^{A}
H.S.D. at 5 %		0.066	0.083	0.16	0.20	N.S.	N.S.	0.021	0.029
F test	V x P	N.S.	N.S.	N.S.	N.S.	**	**	N.S.	N.S.
Prob.	V x K	**	**	**	**	N.S.	N.S.	**	**
	P x K	**	**	**	**	N.S.	N.S.	N.S.	N.S.
	V x P x K	N.S.	N.S.	**	**	N.S.	N.S.	N.S.	N.S.

** Significant and N.S. No significant

Table 11: Mean values of fat content, crude fiber content, total carbohydrate content and ash content as affected by mean effect of wheat varieties, phosphorus fertilizer rates and potassium fertilizer rates during 2019-20 and 2020-21 seasons.

Trait		Fat content (%)		Crude fiber content (%)		Total carbohydrate content (%)		Ash content (%)	
Season		2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Wheat varieties (V)									
Misr 3		1.949^{B}	2.004^{B}	2.104^{A}	2.049^{A}	78.81^{B}	78.02^{B}	4.876^{B}	4.925^{B}
Sakha 95		2.096^{A}	2.150^{A}	2.150^{A}	2.096^{A}	77.42^{C}	76.84^{C}	5.035^{A}	5.094^{A}
Giza 171		1.832^{C}	1.903^{C}	2.003^{B}	1.932^{B}	80.01^{A}	79.56^{A}	4.740^{C}	4.839^{B}
H.S.D. at 5 %		0.102	0.092	0.097	0.087	0.29	0.29	0.130	0.119
Phosphorus fertilizer rates kg P_2O_5 fed^{-1} (P)									
0		1.906^{B}	1.969^{B}	2.200^{A}	2.149^{A}	79.45^{A}	78.78^{A}	4.851	4.911
15		1.960^{AB}	2.024^{A}	2.086^{B}	2.016^{B}	78.71^{B}	78.03^{B}	4.877	4.950
30		2.011^{A}	2.064^{A}	1.971^{C}	1.912^{C}	78.07^{C}	77.61^{C}	4.924	4.997
H.S.D. at 5 %		0.059	0.051	0.055	0.042	0.15	0.16	N.S.	N.S.
Potassium fertilizer rates kg K_2O fed^{-1} (K)									
0		1.821^{C}	1.875^{C}	2.184^{A}	2.117^{A}	80.68^{A}	79.83^{A}	4.772^{C}	4.825^{C}
24		1.948^{B}	2.021^{B}	2.092^{B}	2.036^{B}	78.85^{B}	78.23^{B}	4.889^{B}	4.959^{B}
48		2.108^{A}	2.162^{A}	1.981^{C}	1.924^{C}	76.70^{C}	76.35^{C}	4.990^{A}	5.073^{A}
H.S.D. at 5 %		0.059	0.051	0.055	0.042	0.15	0.16	0.078	0.072
F test	V x P	**	**	**	**	**	**	N.S.	N.S.
Prob.	V x K	**	**	N.S.	N.S.	**	**	**	**
	P x K	**	**	**	**	**	**	N.S.	N.S.
	V x P x K	N.S.	N.S.	N.S.	N.S.	**	**	N.S.	N.S.

** Significant and N.S. No significant

season in addition to kernel potassium content in the both season were not significant. Kernels of Misr 3 variety significantly produced the highest mean values in nitrogen content (2.666 and 2.615 %) and crude protein content (15.19 and 14.91 %) in the both seasons, respectively. The highest mean values of phosphorus content (0.536 and 0.544 %), potassium content (0.556 and 0.564 %), fat content (2.096 and 2.150 %), crude fiber content (2.150 and 2.096 %) and ash content (5.035 and 5.094 %) were obtained from kernels of Sakha 95 variety in both seasons, respectively. Kernels of Giza 171 variety significantly produced the highest total carbohydrate content (80.01 and 79.56 %) in the both seasons, respectively. These differences in kernels chemical properties may be due to the genetic differences between wheat varieties. The results agree with those reported by [1, 5, 19, 20].

Effect of Phosphorus Fertilizer Rates: Results in Tables 10 and 11, indicated that increasing phosphorus fertilizer rates from 0 up to 30 kg P_2O_5 fed^{-1} caused significant increments in mean values of most kernels chemical properties of wheat under study except, mean values of kernel crude fiber content and kernel total carbohydrate content were significantly decreased with rising phosphorus fertilizer rates during 2019-20 and 2020-21 seasons. Meanwhile, mean values of kernel potassium content and kernel ash content were not significantly affected in the both seasons. But, the differences between phosphorus fertilizer rates of 15 and 30 kg P_2O_5 fed^{-1} on kernel nitrogen content, kernel phosphorus content and kernel fat content did not reach the level of significance in the both seasons. Wheat kernels produced from plants treated with 30 kg P_2O_5 fed^{-1} significantly gave the highest mean values of nitrogen content (2.528 and 2.494 %), crude protein content (14.41 and 14.22 %), phosphorus content (0.524 and 0.534 %) and fat content (2.011 and 2.064 %) as well as significantly recorded the lowest mean values of crude fiber content (1.971 and 1.912 %) and total carbohydrate content (78.07 and 77.61 %) in the both seasons, respectively. Such results stated the vital role of phosphorus fertilization in improving the chemical properties of wheat kernels. These results are in harmony with those obtained by [19, 24, 32].

Effect of Potassium Fertilizer Rates: Results in Tables 10 and 11, showed that kernels chemical properties of wheat, *i.e.* nitrogen content, crude protein content, potassium content, fat content, crude fiber content, total carbohydrate content and ash content were significantly affected by potassium fertilizer rates, *i.e.* 0, 24 and 48 kg K_2O fed^{-1}. While, mean values of kernel phosphorus content were not significant in the both seasons. In general, the higher potassium rate (48 kg K_2O fed^{-1}) was more effective in kernels chemical properties of wheat, also, produced the highest mean values of nitrogen content (2.602 and 2.576 %), crude protein content (14.83 and 14.68 %), potassium content (0.548 and 0.559 %), fat content (2.108 and 2.162 %) and ash content (4.990 and 5.073 %) as well as significantly recorded the lowest mean

Table 12: Mean values of phosphorus content, fat content, crude fiber content and total carbohydrate content in wheat kernels as affected by the interaction between wheat varieties and phosphorus fertilizer rates during 2019-20 and 2020-21 seasons

Season		2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Variety	P rate kg P_2O_5 fed^{-1}	P content (%)		Fat content (%)		Crude fiber content (%)		Total carbohydrate content (%)	
Misr 3	0	0.464^{CD}	0.473^{BC}	1.898^{DEF}	1.949^{DEF}	2.207^{AB}	2.164^{AB}	79.36^{C}	78.60^{C}
	15	0.497^{ABC}	0.504^{ABC}	1.949^{CDE}	2.010^{CDE}	2.117^{BCD}	2.056^{CD}	78.83^{D}	77.99^{D}
	30	0.522^{ABC}	0.534^{AB}	2.000^{BCD}	2.054^{BCD}	1.990^{DEF}	1.926^{EF}	78.23^{E}	77.46^{E}
Sakha 95	0	0.506^{ABC}	0.513^{ABC}	2.052^{ABC}	2.104^{ABC}	2.252^{A}	2.204^{A}	78.19^{E}	77.58^{E}
	15	0.542^{AB}	0.550^{AB}	2.094^{AB}	2.156^{AB}	2.156^{ABC}	2.105^{BC}	77.43^{F}	76.67^{F}
	30	0.560^{A}	0.568^{A}	2.142^{A}	2.192^{A}	2.043^{CDE}	1.979^{DE}	76.63^{G}	76.25^{G}
Giza 171	0	0.422^{D}	0.431^{C}	1.767^{F}	1.855^{F}	2.142^{ABC}	2.077^{BC}	80.80^{A}	80.14^{A}
	15	0.460^{CD}	0.467^{BC}	1.838^{EF}	1.907^{EF}	1.984^{EF}	1.886^{EF}	79.86^{B}	79.41^{B}
	30	0.489^{BCD}	0.500^{ABC}	1.890^{DEF}	1.945^{DEF}	1.882^{F}	1.831^{F}	79.35^{C}	79.12^{B}
H.S.D. at 5 %		0.068	0.084	0.137	0.119	0.128	0.097	0.35	0.38

values of crude fiber content (1.981 and 1.924 %) and total carbohydrate content (76.70 and 76.35 %) in the both seasons, respectively. The increase in chemical properties of wheat kernels associated with increasing potassium fertilizer rates may be attributed to the role of potassium in many physiological processes, *i.e.* water relations, photosynthesis, assimilate transport, protein synthesis and enzyme activation can have direct consequences on kernels chemical properties of wheat. These results are in compatible with those found by [6, 24, 32, 42].

Effect of the Interaction Between Wheat Varieties and Phosphorus Fertilizer Rates: Phosphorus content, fat content, crude fiber content and total carbohydrate content in wheat kernels were significantly affected by interaction between wheat varieties (Misr 3, Sakha 95 and Giza 171) and phosphorus fertilizer rates (0, 15 and 30 kg P_2O_5 fed^{-1}). While, nitrogen content, crude protein content, potassium content and ash content in wheat kernels were not significant by interaction between wheat varieties and phosphorus fertilizer rates in the both seasons, as shown in Table 10 and 11. Data in Table 12 showed that wheat kernels produced from Sakha 95 variety treated with 30 kg P_2O_5 fed^{-1} recorded the highest mean values of phosphorus content (0.560 and 0.568 %) and fat content (2.142 and 2.192 %) as well as gave the lowest mean values of total carbohydrate content (76.63 and 76.25 %) also, the same variety without phosphorus application gave the highest kernel crude fiber content (2.252 and 2.204 %) in both seasons, respectively. Wheat kernels produced from Giza 171 plants treated with 30 kg P_2O_5 fed^{-1} produced the lowest mean values of crude fiber content (1.882 and 1.831 %) in the respective both seasons. Meanwhile, with the same wheat variety without phosphorus application recorded the highest mean values of total carbohydrate content (80.80 and 80.14 %) in the both seasons, respectively. Similar results were also reported by [19], whose found variations in kernels chemical properties between wheat varieties and phosphorus fertilizer rates interaction.

Effect of the Interaction Between Wheat Varieties and Potassium Fertilizer Rates: Results in Tables 10 and 11 indicated that significant effect of the interaction between wheat varieties and potassium fertilizer rates obtained for almost kernels chemical properties under study except, mean values of phosphorus content and crude fiber content were not significantly affected by the interaction in the both seasons. Data in Table 13 showed that wheat kernels produced from Misr 3 variety treated with 48 kg K_2O fed^{-1} recorded the highest mean values in nitrogen content (2.740 and 2.726 %) and crude protein content (15.62 and 15.54 %) during the both seasons, respectively. Wheat kernels produced from Sakha 95 variety when received 48 kg K_2O fed^{-1} gave the highest mean values of potassium content (0.580 and 0.588 %), fat content (2.231 and 2.278 %) and ash content (5.127 and 5.229 %) in addition to, recorded the lowest mean values of total carbohydrate content (75.12 and 74.96 %) in the both seasons, respectively. Meanwhile, Wheat kernels produced from Giza 171 variety without potassium application gave the highest mean values of total carbohydrate content (82.16 and 81.04 %) in both seasons, respectively. Similar results were also reported by [6, 7] whose found variations in kernels chemical properties between wheat varieties and potassium fertilizer rates interaction.

Effect of the Interaction Between Phosphorus and Potassium Fertilizer Rates: Nitrogen content, crude protein content, fat content, crude fiber content and total carbohydrate content in wheat kernels were significantly

Table 13: Mean values of kernels properties of wheat as affected by the interaction between wheat varieties and potassium fertilizer rates during 2019-20 and 2020-21 seasons.

Season		2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Variety	K rate kg K_2O fed^{-1}	N content (%)		Crude protein content (%)		K content (%)	
Misr 3	0	2.572^{BC}	2.488^{BCD}	14.66^{BC}	14.18^{C}	0.489^{CD}	0.498^{BC}
	24	2.685^{AB}	2.632^{AB}	15.30^{A}	15.00^{B}	0.522^{BC}	0.529^{ABC}
	48	2.740^{A}	2.726^{A}	15.62^{A}	15.54^{A}	0.547^{AB}	0.559^{AB}
Sakha 95	0	2.141^{F}	2.099^{E}	12.21^{F}	11.96^{E}	0.526^{BC}	0.533^{AB}
	24	2.325^{E}	2.295^{DE}	13.25^{E}	13.08^{D}	0.562^{AB}	0.570^{A}
	48	2.467^{CDE}	2.422^{CD}	14.06^{D}	13.81^{C}	0.580^{A}	0.588^{A}
Giza 171	0	2.381^{DE}	2.322^{D}	13.57^{E}	13.24^{D}	0.451^{D}	0.460^{C}
	24	2.511^{CD}	2.477^{BCD}	14.31^{CD}	14.12^{C}	0.489^{CD}	0.496^{BC}
	48	2.601^{ABC}	2.581^{ABC}	14.83^{B}	14.71^{B}	0.518^{BC}	0.529^{ABC}
H.S.D. at 5 %		0.153	0.194	0.37	0.46	0.049	0.068
Variety	K rate kg K_2O fed^{-1}	Fat content (%)		Total carbohydrate content (%)		Ash content (%)	
Misr 3	0	1.797^{D}	1.858^{EF}	80.41^{B}	79.73^{B}	4.755^{CDE}	4.819^{CD}
	24	1.945^{C}	2.020^{CD}	78.90^{E}	78.24^{D}	4.890^{BCD}	4.931^{BE}
	48	2.105^{AB}	2.134^{BC}	77.10^{G}	76.09^{F}	4.983^{AB}	5.026^{B}
Sakha 95	0	1.945^{C}	2.011^{D}	79.45^{D}	78.74^{C}	4.937^{BC}	4.961^{BC}
	24	2.113^{AB}	2.163^{AB}	77.68^{F}	76.81^{E}	5.040^{AB}	5.092^{AB}
	48	2.231^{A}	2.278^{A}	75.12^{H}	74.96^{G}	5.127^{A}	5.229^{A}
Giza 171	0	1.721^{D}	1.756^{F}	82.16^{A}	81.04^{A}	4.623^{E}	4.695^{D}
	24	1.785^{D}	1.879^{E}	79.97^{C}	79.64^{B}	4.738^{DE}	4.855^{CD}
	48	1.989^{BC}	2.072^{BCD}	77.88^{F}	78.00^{D}	4.859^{BCD}	4.965^{BC}
H.S.D. at 5 %		0.137	0.119	0.35	0.38	0.181	0.168

Table 14: Mean values of kernels properties of wheat as affected by the interaction between phosphorus and potassium fertilizer rates 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
P rate kg P_2O_5 fed^{-1}	K rate kg K_2O fed^{-1}	N content (%)		Crude protein content (%)		Fat content (%)		Crude fiber content (%)		Total carbohydrate content (%)	
0	0	2.314^{E}	2.244^{D}	13.19^{F}	12.79^{E}	1.774^{F}	1.804^{E}	2.306^{A}	2.268^{A}	81.40^{A}	80.48^{A}
	24	2.459^{B-E}	2.413^{A-D}	14.02^{CD}	13.75^{BC}	1.911^{C-F}	1.998^{CD}	2.197^{AB}	2.151^{B}	79.38^{D}	78.82^{D}
	48	2.587^{AB}	2.563^{A}	14.74^{A}	14.61^{A}	2.032^{BC}	2.106^{BC}	2.097^{BCD}	2.027^{CD}	77.58^{G}	77.03^{G}
15	0	2.373^{DE}	2.313^{CD}	13.53^{EF}	13.18^{DE}	1.837^{EF}	1.909^{DE}	2.181^{ABC}	2.106^{BC}	80.72^{B}	79.74^{B}
	24	2.501^{A-D}	2.451^{ABC}	14.25^{BC}	13.97^{B}	1.953^{CDE}	2.024^{BCD}	2.100^{BCD}	2.038^{CD}	78.80^{E}	78.18^{E}
	48	2.605^{AB}	2.576^{A}	14.85^{A}	14.68^{A}	2.091^{AB}	2.139^{AB}	1.976^{DE}	1.904^{EF}	76.60^{H}	76.16^{H}
30	0	2.407^{CDE}	2.352^{BCD}	13.72^{DE}	13.41^{CD}	1.851^{DEF}	1.912^{DE}	2.065^{CD}	1.977^{DE}	79.91^{C}	79.29^{C}
	24	2.562^{ABC}	2.540^{AB}	14.60^{AB}	14.48^{A}	1.979^{BCD}	2.040^{BC}	1.979^{DE}	1.918^{EF}	78.37^{F}	77.69^{F}
	48	2.616^{A}	2.590^{A}	14.91^{A}	14.76^{A}	2.201^{A}	2.239^{A}	1.870^{E}	1.841^{F}	75.93^{I}	75.85^{H}
H.S.D. at 5 %		0.153	0.194	0.37	0.46	0.137	0.119	0.128	0.097	0.35	0.38

affected by interaction between phosphorus fertilizer rates (0, 15 and 30 kg P_2O_5 fed^{-1}) and potassium fertilizer rates (0, 24 and 48 kg K_2O fed^{-1}). While, mean values of phosphorus content, potassium content and ash content in wheat kernels were not significant by interaction between phosphorus and potassium fertilizer rates in the both seasons, as shown in Tables 10 and 11. Results in Table 14 recorded that wheat kernels produced from wheat plants treated with 30 kg P_2O_5 and 48 kg K_2O fed^{-1} recorded the highest mean values of nitrogen content (2.616 and 2.590 %), crude protein content (14.91 and 14.76 %) and fat content (2.201 and 2.239 %) in addition to, gave the lowest mean values of crude fiber content (1.870 and 1.841 %) and total carbohydrate content (75.93 and 75.85 %) in the both seasons, respectively. On the other hand, growing wheat without phosphorus and potassium fertilizers added markedly recorded the lowest mean values in kernel nitrogen content (2.314 and 2.244 %), kernel crude protein content (13.19 and 12.79 %) and kernel fat content (1.774 and 1.804 %) as well as, gave the highest mean values of kernel crude fiber content (2.306 and 2.268 %) and kernel total carbohydrate content

Table 15: Mean values of crude protein content and total carbohydrate content (%) of wheat as affected by the interaction among wheat varieties, phosphorus and phosphorus fertilizer rates during 2020-21 seasons

Season			2019-20	2020-21	2019-20	2020-21
Variety	P rate kg P_2O_5 fed^{-1}	K rate kg K_2O fed^{-1}	Crude protein content (%)		Total carbohydrate content (%)	
Misr 3	0	0	14.27^{E-I}	13.78^{H-K}	81.33^{C}	80.45^{BC}
		24	15.15^{A-D}	14.85^{A-F}	79.13^{GHI}	78.69^{GH}
		48	15.52^{ABC}	15.43^{ABC}	77.63^{KL}	76.67^{K}
	15	0	14.75^{C-G}	14.26^{D-J}	80.49^{DE}	79.66^{CDE}
		24	15.33^{A-D}	14.96^{A-E}	78.89^{HIJ}	78.39^{GHI}
		48	15.62^{AB}	15.54^{AB}	77.10^{LM}	75.93^{KL}
	30	0	14.96^{A-E}	14.50^{C-I}	79.43^{F-I}	79.07^{EFG}
		24	15.43^{ABC}	15.20^{A-D}	78.68^{IJ}	77.63^{IJ}
		48	15.70^{A}	15.64^{A}	76.57^{MN}	75.67^{L}
Sakha 95	0	0	11.94^{O}	11.61^{N}	80.05^{DEF}	79.50^{DEF}
		24	12.81^{LMN}	12.64^{LM}	78.23^{JK}	77.51^{J}
		48	13.96^{H-K}	13.76^{H-K}	76.29^{N}	75.73^{L}
	15	0	12.22^{NO}	12.01^{MN}	79.52^{FGH}	78.59^{GH}
		24	13.18^{KLM}	12.93^{KLM}	77.69^{KL}	76.64^{K}
		48	14.08^{G-J}	13.80^{G-K}	75.09^{O}	74.79^{M}
	30	0	12.46^{MNO}	12.27^{MN}	78.77^{HIJ}	78.11^{HIJ}
		24	13.77^{IJK}	13.67^{IJK}	77.13^{LM}	76.26^{KL}
		48	14.15^{F-I}	13.86^{F-K}	73.99^{P}	74.37^{M}
Giza 171	0	0	13.36^{JKL}	12.98^{KLM}	82.81^{A}	81.48^{A}
		24	14.08^{G-J}	13.78^{H-K}	80.79^{CD}	80.24^{BCD}
		48	14.75^{C-G}	14.64^{B-I}	78.81^{HIJ}	78.71^{FGH}
	15	0	13.61^{IJK}	13.28^{JKL}	82.17^{AB}	80.96^{AB}
		24	14.25^{E-I}	14.01^{F-J}	79.81^{EFG}	79.51^{DEF}
		48	14.84^{B-G}	14.72^{A-H}	77.61^{KL}	77.76^{IJ}
	30	0	13.74^{IJK}	13.45^{JKL}	81.52^{BC}	80.67^{B}
		24	14.61^{D-H}	14.56^{B-I}	79.30^{F-I}	79.17^{EFG}
		48	14.89^{B-F}	14.78^{A-G}	77.23^{LM}	77.52^{J}
H.S.D. at 5 %	0.81	1.03	0.79	0.84		

(81.40 and 80.48 %) in the both seasons, respectively. Such results are in accordance with those obtained by [24, 32], which reported that there was significantly difference among interaction between phosphorus and potassium fertilizer rates of mean values of chemical properties in wheat kernels.

Effect of the Interaction among Wheat Varieties, Phosphorus and Potassium Fertilizer Rates: The effect of the interaction among the three factors under study on mean values of crude protein content and total carbohydrate content in wheat kernels which significant in the both seasons. While, mean values of nitrogen content, phosphorus content, potassium content, fat content, crude fiber content and ash content in wheat kernels were not significantly affected by these interactions (F test probability are shown in Tables 10 and 11). Results in Table 15 showed that wheat kernels produced from Misr 3 variety treated with 30 kg P_2O_5 and 48 kg K_2O fed^{-1} recorded the highest mean values of crude protein content (15.70 and 15.64 %) in the both seasons, respectively. On the other hand, the lowest mean values of crude protein content (11.94 and 11.61 %) were obtained from wheat kernels produced of Giza 171 variety without phosphorus and potassium application in both seasons, respectively. Wheat kernels produced from Giza 171 variety without phosphorus and potassium application gave the highest mean values of total carbohydrate content (82.81 and 81.48 %) in both seasons, respectively. On the other hand, the lowest mean values of total carbohydrate content (73.99 and 74.37 %) were obtained from wheat kernels produced from Sakha 95 variety when received 30 kg P_2O_5 and 48 kg K_2O fed^{-1} gave the lowest mean values of total carbohydrate content (73.99 and 74.37 %) in the both seasons, respectively. Such results are in accordance with those obtained by [13].

C) Infestation of Wheat Kernels by *S. oryzae*:

Effect of Varieties and Fertilizers Rates: Results obtained in Table 16 showed that Sakha 95 variety, rates of 30 P_2O_5 fed^{-1} (P) and 48 kg K_2O fed^{-1} (K) had the best effects for all tested parameters, since Sakha 95 variety was the tolerant among the three tested wheat varieties,

Table 16: Mean values of natural damage (%) after one year post harvest, susceptibility (Non-choice) and preferability (choice) as affected by mean effect of wheat varieties, phosphorus fertilizer rates and potassium fertilizer rates during 2019-20 and 2020-21 seasons.

Trait	Natural damage (%) after one year post harvest		Choice (Preferability): No. of insects after 5 days release		Non-choice (Susceptibility): No. of adults emergence (F_1)		Non-choice (Susceptibility): Kernels weight loss (%)	
Season	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Wheat varieties (V)								
Misr 3	39.59^B	41.63^B	3.619^B	3.826^B	2.770^B	2.930^B	16.62^B	17.58^B
Sakha 95	30.93^C	31.93^C	2.648^C	2.778^C	2.030^C	2.121^C	12.18^C	12.73^C
Giza 171	49.19^A	52.70^A	4.563^A	4.881^A	3.501^A	3.747^A	21.00^A	22.48^A
H.S.D. at 5 %	2.15	2.23	0.230	0.218	0.176	0.177	1.06	1.06
Phosphorus fertilizer rates kg P_2O_5 fed^{-1} (P)								
0	46.22^A	48.63^A	4.270^A	4.489^A	3.274^A	3.444^A	19.65^A	20.66^A
15	40.00^B	42.15^B	3.637^B	3.859^B	2.789^B	2.951^B	16.73^B	17.70^B
30	33.48^C	35.48^C	2.922^C	3.137^C	2.238^C	2.403^C	13.43^C	14.42^C
H.S.D. at 5 %	1.00	1.08	0.091	0.105	0.078	0.082	0.47	0.49
Potassium fertilizer rates kg K_2O fed^{-1} (K)								
0	43.89^A	46.22^A	4.022^A	4.248^A	3.087^A	3.254^A	18.52^A	19.52^A
24	39.52^B	41.67^B	3.585^B	3.789^B	2.743^B	2.907^B	16.46^B	17.44^B
48	36.30^C	38.37^C	3.222^C	3.448^C	2.472^C	2.637^C	14.83^C	15.82^C
H.S.D. at 5 %	1.00	1.08	0.091	0.105	0.078	0.082	0.47	0.49
F test Prob. V x P	**	**	**	**	**	**	**	**
V x K	**	**	N.S.	N.S.	**	**	**	**
P x K	**	**	**	**	**	**	**	**
V x P x K	**	**	N.S.	N.S.	N.S.	N.S.	**	**

** Significant and N.S. No significant

it has the reduced % damage one year post harvest (30.93 and 31.93 %), harboured the least number of *S. oryzae* insects (2.648 and 2.778) and prevented the emergence of adults achieving the reduced weight loss in the both seasons, respectively. the rates of 30 P_2O_5 fed^{-1} (P) and 48 kg K_2O fed^{-1} (K) had the same direct of Sakha 95 variety where they inhibited the damage ability of *S. oryzae* following by reduced kernels weight loss % through the two seasons of study 2019-20 and 2020-21. The interaction of V x P and P x K achieved significant effect for the all tested parameters. No response was found with (preferability and susceptibility) and emergence (F_1) for the interaction of V x K and V x P x K, respectively.

Similarly, variety of Sakha 95, rates of 30 P_2O_5 fed^{-1} and 48 kg K_2O fed^{-1} presented the highest net grain yield (kg fed^{-1}) and the highest % germination followed by Misr 3 then Giza 171, and rates of 15 P_2O_5 fed^{-1} then zero P_2O_5 fed^{-1} for phosphorus fertilizers, and rates of 24 K_2O fed^{-1} then without application for potassium fertilizers, respectively (Table, 17). There were significant differences between the varieties and between the rates of the two fertilizers in the both seasons of the current study in respect to the all tested parameters. The interactions between varieties and rates of P and K showed significant effect on the grain yield fed^{-1}, net grain yield fed^{-1}, loss weight while % germination was not affected by these interactions. The interaction of P x K indicated to significant effect on the all tested parameters mentioned above except, the weight loss (%) and % germination. The interaction between V x P x K manifested highly significant with the remainder parameters. In general the increasing of rate fertilizers of P or K increased the net grain yield fed^{-1} and reduced the % weight loss and the emerged adults in the both seasons (Tables 16 and 17).

Effect of the Interaction Between Varieties and Phosphorus Fertilizers Rates: Results in Tables 16 and 17 indicated significant effect in respect to most of the tested parameters. Data in Table 18 showed Sakha 95 variety had the least natural damage, the least No. of insects after 5 days release (preferability) and the least No. of emerged adults and weight loss (%) as non-choice (susceptibility). For example Sakha 95 at 30 kg P_2O_5 fed^{-1} had the least values of the parameters of % natural damage (24.22 and 25.22 %), No. of insects after 5 days release (preferability) [1.833 and 1.978], No. of emerged adults (1.409 and 1.511), % weight loss (8.45 and 9.07 %) and loss grain yield (330.14 and 368.22 kg fed^{-1}) in the both seasons respectively. Also, data in Table 18 presented that Sakha 95 achieved the highest of grain yield fed^{-1} and net grain yield fed^{-1} at the rate of 30 kg P_2O_5 fed^{-1} in the two seasons. According to these results

Table 17: Mean values of grain yield (kg fed^{-1}), net grain yield (kg fed^{-1}), loss grain yield (kg fed^{-1}) and germination percentage (%) as affected by mean effect of wheat varieties, phosphorus fertilizer rates and potassium fertilizer rates during 2019-20 and 2020-21 seasons

Trait	Grain yield (kg fed^{-1})		Net grain yield (kg fed^{-1})		Loss grain yield (kg fed^{-1})		Germination (%)	
Season	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Wheat varieties (V)								
Misr 3	3461.85^{B}	3625.56^{B}	2894.05^{B}	2996.78^{B}	567.81^{B}	628.77^{B}	40.52^{B}	37.37^{B}
Sakha 95	3667.78^{A}	3802.96^{A}	3229.73^{A}	3328.53^{A}	438.05^{C}	474.44^{C}	49.07^{A}	47.07^{A}
Giza 171	3409.26^{C}	3575.56^{B}	2699.20^{C}	2778.73^{C}	710.06^{A}	796.83^{A}	30.56^{C}	26.30^{C}
H.S.D. at 5 %	49.90	61.41	68.71	52.32	31.40	46.27	1.59	2.23
Phosphorus fertilizer rates kg P_2O_5 fed^{-1} (P)								
0	3253.70^{C}	3366.67^{C}	2619.48^{C}	2676.47^{C}	634.23^{A}	690.19^{A}	33.70^{C}	30.37^{C}
15	3515.93^{B}	3681.11^{B}	2933.59^{B}	3035.21^{B}	582.33^{B}	645.90^{B}	39.89^{B}	36.85^{B}
30	3769.26^{A}	3956.30^{A}	3269.91^{A}	3392.35^{A}	499.35^{C}	563.94^{C}	46.56^{A}	43.52^{A}
H.S.D. at 5 %	24.77	19.47	26.75	23.65	16.88	18.59	1.08	1.08
Potassium fertilizer rates kg K_2O fed^{-1} (K)								
0	3322.22^{C}	3464.07^{C}	2715.48^{C}	2796.58^{C}	606.74^{A}	667.49^{A}	35.96^{C}	32.78^{C}
24	3546.67^{B}	3703.33^{B}	2972.00^{B}	3067.58^{B}	574.67^{B}	635.75^{B}	40.52^{B}	37.33^{B}
48	3670.00^{A}	3836.67^{A}	3135.50^{A}	3239.87^{A}	534.50^{C}	596.79^{C}	43.67^{A}	40.63^{A}
H.S.D. at 5 %	24.77	19.47	26.75	23.65	16.88	18.59	1.08	1.08
F test V x P	**	**	**	**	**	**	N.S.	N.S.
Prob. V x K	**	**	**	**	**	**	N.S.	N.S.
P x K	**	**	**	**	**	**	**	**
V x P x K	**	**	**	**	N.S.	N.S.	N.S.	N.S.

** Significant and N.S. No significant

Table 18: Mean values of insect traits as affected by the interaction between wheat varieties and phosphorus fertilizer rates during 2019-20 and 2020-21 seasons

Season		2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
				Choice (Preferability)		Non-choice (Susceptibility)			
Variety	P rate (kg P_2O_5 fed^{-1})	Natural damage (%) after one year post harvest		No. of insects after 5 days release		No. of adults emergence (F1)		Kernels weight loss (%)	
Misr 3	0	46.44^{C}	48.67^{C}	4.322^{C}	4.522^{C}	3.310^{C}	3.471^{C}	19.86^{C}	20.83^{C}
	15	39.56^{E}	41.56^{D}	3.633^{E}	3.856^{D}	2.779^{E}	2.937^{D}	16.67^{E}	17.62^{D}
	30	32.78^{F}	34.67^{F}	2.900^{F}	3.100^{F}	2.221^{F}	2.381^{F}	13.33^{F}	14.29^{F}
Sakha 95	0	37.56^{E}	38.56^{E}	3.433^{E}	3.544^{E}	2.623^{E}	2.704^{E}	15.74^{E}	16.23^{E}
	15	31.00^{F}	32.00^{G}	2.678^{F}	2.811^{G}	2.059^{F}	2.148^{G}	12.35^{F}	12.89^{G}
	30	24.22^{G}	25.22^{H}	1.833^{G}	1.978^{H}	1.409^{G}	1.511^{H}	8.45^{G}	9.07^{H}
Giza 171	0	54.67^{A}	58.67^{A}	5.056^{A}	5.400^{A}	3.890^{A}	4.156^{A}	23.34^{A}	24.93^{A}
	15	49.44^{B}	52.89^{B}	4.600^{B}	4.911^{B}	3.528^{B}	3.768^{B}	21.17^{B}	22.61^{B}
	30	43.44^{D}	46.56^{C}	4.033^{D}	4.333^{C}	3.084^{D}	3.318^{C}	18.51^{D}	19.91^{C}
H.S.D. at 5 %		2.33	2.51	0.213	0.244	0.182	0.191	1.09	1.15
Variety	P rate (kg P_2O_5 fed^{-1})	Grain yield (kg fed^{-1})		Net grain yield (kg fed^{-1})		Loss grain yield (kg fed^{-1})		Germination (%)	
Misr 3	0	3212.22^{E}	3336.67^{F}	2576.42^{F}	2643.94^{G}	635.80^{C}	692.73^{B}	33.67	30.33
	15	3466.67^{C}	3635.56^{D}	2890.84^{D}	2997.35^{D}	575.82^{D}	638.20^{C}	40.67	37.44
	30	3706.67^{B}	3904.44^{B}	3214.88^{B}	3349.05^{B}	491.79^{F}	555.39^{D}	47.22	44.33
Sakha 95	0	3394.44^{D}	3500.00^{E}	2861.71^{D}	2933.78^{E}	532.73^{E}	566.22^{D}	42.56	40.44
	15	3673.33^{B}	3813.33^{C}	3222.06^{B}	3324.45^{B}	451.27^{G}	488.88^{E}	48.78	47.00
	30	3935.56^{A}	4095.56^{A}	3605.41^{A}	3727.34^{A}	330.14^{H}	368.22^{F}	55.89	53.78
Giza 171	0	3154.44^{E}	3263.33^{G}	2420.30^{G}	2451.70^{H}	734.15^{A}	811.64^{A}	24.89	20.33
	15	3407.78^{D}	3594.44^{D}	2687.87^{E}	2783.82^{F}	719.91^{A}	810.63^{A}	30.22	26.11
	30	3665.56^{B}	3868.89^{B}	2989.44^{C}	3100.67^{C}	676.12^{B}	768.22^{A}	36.56	32.44
H.S.D. at 5 %		57.60	45.29	62.22	55.00	39.26	43.23	N.S.	N.S.

the Sakha 95 variety with the three rates of phosphorus fertilizer in the two seasons was the premier variety followed by Misr 3 and Giza 171. In general, results in Table 18 evoked that when the rate of phosphorus fertilizer increase the emerged adults and natural damage decreased and the net grain yield increased.

Effect of the Interaction Between Varieties and Phosphorus Fertilizers Rates: Data in Tables 16 and 17 involved significant effect in concerning the most of studied parameters of preferability and susceptibility. Results in Table 19 had the same direction of V x P treatments in Table 18, where variety of Sakha 95 was the

Table 19: Mean values of insect traits as affected by the interaction between wheat varieties and potassium fertilizer rates during 2019-20 and 2020-21 seasons

Season		2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
				Choice (Preferability)		Non-choice (Susceptibility)			
Variety	K rate (kg K_2O fed^{-1})	Natural damage (%) after one year post harvest		No. of insects after 5 days release		No. of adults emergence (F1)		Kernels weight loss (%)	
Misr 3	0	43.89^{C}	46.11^{D}	4.056	4.278	3.109^{C}	3.273^{C}	18.65^{C}	19.64^{D}
	24	39.00^{D}	41.00^{E}	3.567	3.756	2.726^{D}	2.886^{D}	16.35^{D}	17.31^{E}
	48	35.89^{E}	37.78^{F}	3.233	3.444	2.476^{E}	2.630^{E}	14.85^{E}	15.78^{F}
Sakha 95	0	34.44^{E}	35.44^{F}	3.067	3.200	2.354^{E}	2.439^{E}	14.13^{E}	14.63^{F}
	24	31.11^{F}	32.11^{G}	2.689	2.800	2.052^{F}	2.142^{F}	12.31^{F}	12.85^{G}
	48	27.22^{G}	28.22^{H}	2.189	2.333	1.684^{G}	1.782^{G}	10.11^{G}	10.69^{H}
Giza 171	0	53.33^{A}	57.11^{A}	4.944	5.267	3.797^{A}	4.049^{A}	22.78^{A}	24.29^{A}
	24	48.44^{B}	51.89^{B}	4.500	4.811	3.450^{B}	3.693^{B}	20.70^{B}	22.16^{B}
	48	45.78^{C}	49.11^{C}	4.244	4.567	3.256^{C}	3.499^{B}	19.53^{C}	20.99^{C}
H.S.D. at 5 %		2.33	2.51	N.S.	N.S.	0.182	0.191	1.09	1.15
Variety	K rate (kg K_2O fed^{-1})	Grain yield (kg fed^{-1})		Net grain yield (kg fed^{-1})		Loss grain yield (kg fed^{-1})		Germination (%)	
Misr 3	0	3270.00^{F}	3424.44^{G}	2665.29^{G}	2757.54^{G}	604.71^{C}	666.91^{B}	36.22	32.89
	24	3488.89^{E}	3656.67^{E}	2923.59^{DE}	3030.32^{D}	565.30^{CD}	626.34^{BC}	41.11	38.00
	48	3626.67^{C}	3795.56^{C}	3093.26^{C}	3202.49^{C}	533.41^{D}	593.07^{C}	44.22	41.22
Sakha 95	0	3467.78^{E}	3584.44^{F}	2983.60^{D}	3065.91^{D}	484.18^{E}	518.54^{D}	45.22	43.56
	24	3707.78^{B}	3844.44^{B}	3257.76^{B}	3357.74^{B}	450.01^{E}	486.71^{D}	49.22	46.89
	48	3827.78^{A}	3980.00^{A}	3447.82^{A}	3561.93^{A}	379.95^{F}	418.07^{E}	52.78	50.78
Giza 171	0	3228.89^{F}	3383.33^{G}	2497.56^{H}	2566.29^{H}	731.33^{A}	817.04^{A}	26.44	21.89
	24	3443.33^{E}	3608.89^{F}	2734.64^{F}	2814.68^{F}	708.69^{AB}	794.21^{A}	31.22	27.11
	48	3555.56^{D}	3734.44^{D}	2865.41^{E}	2955.20^{E}	690.15^{B}	779.24^{A}	34.00	29.89
H.S.D. at 5 %		57.60	45.29	62.22	55.00	39.26	43.23	N.S.	N.S

one compared to the other two wheat varieties. For example Sakha 95 at the rate of 48 kg K_2O fed^{-1} had the least values of % natural damage (27.22 and 28.22 %), harboured insects (preferability) [2.189 and 2.333], No. of emerged adults (1.684 and 1.782), % weight loss (10.11 and 10.69 %) and loss grain yield (379.95 and 418.07 kg fed^{-1}) in the both seasons respectively. Also, results in Table 19 showed that Sakha 95 performanced the highest of net grain yield (3447.82 and 3561.93 kg fed^{-1}) at the same rate of potassium fertilizer in the two seasons, respectively. According to results in Table 19 Sakha 95 had the desired best characters followed by Misr 3 and Giza 171 wheat varieties.

Effect of the Interaction Between Rates of Phosphorus and Potassium Fertilizers: Data in Tables 16 and 17 indicate that the interaction between the rates of P and K treatments achieved highly significant effect on the all tested criteria of insect infestations and net grain yield fed^{-1}. Results in Table 20 proved that increase of the fertilizer rate of both P x K significant differences between the all treatments from zero to the highest rates. The increase of fertilizer rate decreased the % damage, emerged adults, preferability, % weight loss and net grain yield fed^{-1}. On the other side, they increased yield and net grain yield fed^{-1} as well as % germination. The treatment of 30 kg P_2O_5 x 48 kg K_2O fed^{-1} gave the superior net grain, the highest germination and the least weight loss for the three varieties studied in the two seasons 2019-20 and 2020-21.

Effect of the Interaction among Wheat Varieties, Phosphorus and Potassium Fertilizer Rates: Data exposed in Table 16 and 17 elucidate to significant effect between fertilizer rates with the three wheat varieties in the both seasons under study resulting from the interaction among wheat varieties, P and K fertilizer rates against the all tested parameters of preferability and susceptibility of *S. oryzae* in addition the effect on net yield (kg fed^{-1}) and germination. Results summarized in Table 21 had the same trend found in Table from 16 to 20, since the rates of fertilizers whether wheat varieties showed significant effect on the most tested criteria. These significant effects of fertilizer rate demonstrate the reasonable rate responsible for the tolerant of wheat variety to insect infestation by *S. oryzae*. Results in Table 21 proved that the interaction among wheat variety Sakha 95, 30 kg P_2O_5 and 48 kg K_2O fed^{-1} rate was the premier treatment which achieved the highest net yield and the least wheat weight loss resulting from the least number of emerged adults. In general, Sakha 95 variety was the premier at the all rates of the two tested fertilizers in the

Table 20: Mean values of insect traits as affected by the interaction between phosphorus and potassium fertilizer rates during 2019-20 and 2020-21 seasons

Season		2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
				Choice (Preferability)		Non-choice (Susceptibility)			
P rate (kg P_2O_5 fed^{-1})	K rate (kg K_2O fed^{-1})	Natural damage (%) after one year post harvest		No. of insects after 5 days release		No. of adults emergence (F1)		Kernels weight loss (%)	
0	0	49.56^{A}	52.11^{A}	4.589^{A}	4.800^{A}	3.516^{A}	3.688^{A}	21.09^{A}	22.13^{A}
	24	46.22^{B}	48.56^{B}	4.289^{B}	4.489^{B}	3.279^{B}	3.443^{B}	19.67^{B}	20.66^{B}
	48	42.89^{C}	45.22^{C}	3.933^{C}	4.178^{C}	3.029^{C}	3.200^{C}	18.17^{C}	19.20^{C}
15	0	44.67^{BC}	47.00^{BC}	4.111^{BC}	4.356^{BC}	3.160^{BC}	3.326^{BC}	18.96^{BC}	19.95^{BC}
	24	39.44^{D}	41.56^{D}	3.600^{D}	3.800^{D}	2.754^{D}	2.916^{D}	16.53^{D}	17.49^{D}
	48	35.89^{E}	37.89^{E}	3.200^{E}	3.422^{E}	2.451^{E}	2.611^{E}	14.71^{E}	15.67^{E}
30	0	37.44^{DE}	39.56^{DE}	3.367^{DE}	3.589^{E}	2.584^{DE}	2.748^{DE}	15.51^{DE}	16.49^{DE}
	24	32.89^{F}	34.89^{F}	2.867^{F}	3.078^{F}	2.194^{F}	2.362^{F}	13.17^{F}	14.17^{F}
	48	30.11^{G}	32.00^{G}	2.533^{G}	2.744^{G}	1.936^{G}	2.100^{G}	11.61^{G}	12.60^{G}
H.S.D. at 5 %	2.33	2.51	0.213	0.244	0.182	0.191	1.09	1.15	

P rate (kg P_2O_5 fed^{-1})	K rate (kg K_2O fed^{-1})	Grain yield (kg fed^{-1})		Net grain yield (kg fed^{-1})		Loss grain yield (kg fed^{-1})		Germination (%)	
0	0	3025.56^{H}	3142.22^{H}	2390.38^{I}	2450.11^{I}	635.17^{A}	692.11^{A}	30.22^{G}	26.89^{G}
	24	3304.44^{G}	3392.22^{G}	2657.39^{H}	2694.77^{H}	647.05^{A}	697.45^{A}	34.00^{F}	30.44^{F}
	48	3431.11^{E}	3565.56^{E}	2810.66^{F}	2884.53^{F}	620.46^{A}	681.02^{AB}	36.89^{E}	33.78^{E}
15	0	3364.44^{F}	3505.56^{F}	2729.89^{G}	2809.55^{G}	634.55^{A}	696.00^{A}	35.33^{EF}	32.00^{EF}
	24	3533.33^{D}	3713.33^{D}	2952.84^{E}	3066.98^{E}	580.49^{B}	646.36^{BC}	40.33^{D}	37.44^{D}
	48	3650.00^{C}	3824.44^{C}	3118.04^{C}	3229.10^{C}	531.96^{CD}	595.35^{DE}	44.00^{C}	41.11^{C}
30	0	3576.67^{D}	3744.44^{D}	3026.17^{D}	3130.08^{D}	550.50^{BC}	614.37^{CD}	42.33^{CD}	39.44^{CD}
	24	3802.22^{B}	4004.44^{B}	3305.76^{B}	3440.99^{B}	496.46^{D}	563.45^{E}	47.22^{B}	44.11^{B}
	48	3928.89^{A}	4120.00^{A}	3477.80^{A}	3605.99^{A}	451.09^{E}	514.01^{F}	50.11^{A}	47.00^{A}
H.S.D. at 5 %	57.60	45.29	62.22	55.00	39.26	43.23	2.51	2.51	

two seasons of experiment in storage. Misr 3 follows the Sakha 95 and Giza 171had the later position concerning the tolerant to infestation or the net grain yield (kg fed^{-1}).

In a similar study conducted by [72] on the resistance against rice weevil (*S. oryzae*), the extreme wheat genotypes differed by at least 2-3 fold in the number of damage grains, percent weight loss and adult population during an experiment conducted over five months. In turn, [73] found a 5-fold difference in the number of *S. oryzae* after 160-day of three wheat cultivar grains. Similarly, [59] determined significant differences of the number of offspring and the mass of produced dust between two bread wheat (cvs. Begra and Korweta) and durum wheat (cv. LGR896/64 a). The phenomenon of various wheat cultivars susceptibility to pest damage is related to many chemical compounds, such as the content of total protein or gluten, total lipids and cuticular lipids [74-77] and physical kernel features [59, 73], but it is still not fully explained. According to [78], maize kernel resistance against maize weevil (*Sitophilus jeamais*) and large grain borer (*Postephanus truncates*) is manifested by antibiosis and antixenosis mechanisms. The cited authors concluded that kernel-pest interactions are determined by biophysical factors (pericarp thickness/toughness, kernel hardness and endosperm vitreosity) and biochemical factors (hydroxycinnamic acids, hydroxyproline-rich glycoproteins, extensis, jeins, arabinxylans, peroxidises and phenolic acid amides) under the control of genetic factors [79].

Balanced NPK fertilizer decreased the aphid population density significantly [80]. [81] reported that protection and increasing the productions of wheat will be highly appreciated; the cooperation between plant production and plant production specialists is highly needed to reach this aim. Many studies suggest that fertilizer may effect the physiologically susceptibility of a crop to plants [82]. Soil fertility may also increase the physiological susceptibility in crop plants to insect pests by either affecting the resistance of individual plant to attack or by altering plant acceptability to certain phytophagae [83]. [84] highlighted the importance of physical and chemical properties for protecting the seeds of faba bean against the insect attack and these reports must be taken in consideration for having resistant or tolerant faba bean varieties to insect invading. Potassium is among the macro nutrients which are taken up by plants in large amount. It plays significant roles in transportation of water, nutrients, nitrogen utilization and stimulation of early growth and insect and disease resistance [36].

[35] studied 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} on susceptibility of *S. oryzae* through a non-choice

Table 21: Mean values of natural damage (%) after one year post harvest, kernels weight loss % [susceptibility (Non-choice)], grain yield (kg fed^{-1}) and net grain yield (kg fed^{-1}) as affected by the interaction among wheat varieties, phosphorus and potassium fertilizer rates during 2020-21 seasons

Season			2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
					Non-choice (Susceptibility)					
Variety	P rate kg P_2O_5 fed^{-1}	K rate kg K_2O fed^{-1}	Natural damage (%) after one year post harvest		Kernels weight loss (%)		Grain yield (kg fed^{-1})		Net grain yield (kg fed^{-1})	
Misr 3	0	0	50.33^{BC}	53.00^{BCD}	21.56^{B-E}	22.66^{B-E}	2993.33^{O}	3140.00^{Q}	2348.16^{P}	2428.89^{R}
		24	46.33^{CDE}	48.33^{D-H}	19.84^{DEF}	20.72^{E-I}	3256.67^{MN}	3346.67^{NO}	2610.31^{MN}	2652.81^{OP}
		48	42.67^{EF}	44.67^{GHI}	18.18^{FGH}	19.10^{HIJ}	3386.67^{JKL}	3523.33^{L}	2770.79^{JKL}	2850.12^{LMN}
	15	0	45.00^{DE}	47.00^{E-H}	19.24^{EFG}	20.14^{F-I}	3313.33^{KLM}	3466.67^{LM}	2675.74^{LM}	2768.34^{NO}
		24	38.67^{GH}	40.67^{IJK}	16.28^{HIJ}	17.24^{JKL}	3486.67^{HIJ}	3663.33^{IJ}	2918.90^{HI}	3031.80^{IJK}
		48	35.00^{HIJ}	37.00^{KLM}	14.50^{JKL}	15.48^{LMN}	3600.00^{FGH}	3776.67^{GH}	3077.89^{FG}	3191.91^{GH}
	30	0	36.33^{GHI}	38.33^{JKL}	15.16^{IJK}	16.12^{KLM}	3503.33^{HIJ}	3666.67^{IJ}	2971.96^{GH}	3075.39^{HIJ}
		24	32.00^{IJK}	34.00^{LMN}	12.94^{KLM}	13.98^{MNO}	3723.33^{DEF}	3960.00^{DE}	3241.57^{DE}	3406.35^{E}
		48	30.00^{KL}	31.67^{MNO}	11.88^{MN}	12.76^{OPQ}	3893.33^{BC}	4086.67^{BC}	3431.10^{C}	3565.42^{C}
Sakha 95	0	0	39.67^{FGH}	40.67^{IJK}	16.76^{HIJ}	17.24^{JKL}	3150.00^{N}	3243.33^{P}	2622.01^{MN}	2684.26^{OP}
		24	38.00^{FGH}	39.00^{JKL}	15.96^{HIJ}	16.44^{KL}	3453.33^{IJ}	3540.00^{KL}	2902.23^{HIJ}	2958.09^{JKL}
		48	35.00^{HIJ}	36.00^{KLM}	14.50^{JKL}	15.00^{L-O}	3580.00^{GH}	3716.67^{HIJ}	3060.90^{FG}	3159.01^{GH}
	15	0	35.33^{G-J}	36.33^{KLM}	14.68^{I-L}	15.16^{L-O}	3510.00^{HIJ}	3636.67^{JK}	2994.73^{GH}	3085.26^{HI}
		24	31.33^{JK}	32.33^{MNO}	12.60^{LM}	13.12^{NOP}	3690.00^{EFG}	3846.67^{FG}	3225.15^{DE}	3341.99^{EF}
		48	26.33^{LM}	27.33^{OP}	9.78^{NO}	10.38^{QR}	3820.00^{CD}	3956.67^{DE}	3446.30^{C}	3546.11^{CD}
	30	0	28.33^{KLM}	29.33^{NOP}	10.94^{MN}	11.50^{PQ}	3743.33^{DE}	3873.33^{EFG}	3334.06^{CD}	3428.21^{DE}
		24	24.00^{MN}	25.00^{PQ}	8.38^{OP}	9.00^{RS}	3980.00^{AB}	4146.67^{B}	3645.92^{B}	3773.13^{B}
		48	20.33^{N}	21.33^{Q}	6.04^{P}	6.70^{S}	4083.33^{A}	4266.67^{A}	3836.27^{A}	3980.68^{A}
Giza 171	0	0	58.67^{A}	62.67^{A}	24.96^{A}	26.48^{A}	2933.33^{O}	3043.33^{Q}	2200.98^{Q}	2237.19^{S}
		24	54.33^{AB}	58.33^{AB}	23.22^{AB}	24.82^{AB}	3203.33^{MN}	3290.00^{OP}	2459.64^{OP}	2473.42^{QR}
		48	51.00^{BC}	55.00^{BC}	21.84^{BCD}	23.50^{BCD}	3326.67^{KLM}	3456.67^{LM}	2600.28^{MN}	2644.47^{P}
	15	0	53.67^{B}	57.67^{AB}	22.96^{ABC}	24.56^{ABC}	3270.00^{LMN}	3413.33^{MN}	2519.21^{NO}	2575.05^{PQ}
		24	48.33^{CD}	51.67^{CDE}	20.70^{CDE}	22.12^{C-F}	3423.33^{IJK}	3630.00^{JK}	2714.49^{KLM}	2827.13^{MN}
		48	46.33^{CDE}	49.33^{D-G}	19.84^{DEF}	21.14^{D-H}	3530.00^{HI}	3740.00^{HI}	2829.92^{IJK}	2949.27^{KL}
	30	0	47.67^{CD}	51.00^{C-F}	20.42^{DEF}	21.84^{D-G}	3483.33^{HIJ}	3693.33^{HIJ}	2772.49^{JKL}	2886.64^{LM}
		24	42.67^{EF}	45.67^{F-I}	18.18^{FH}	19.54^{G-J}	3703.33^{DEFG}	3906.67^{EF}	3029.80^{GH}	3143.49^{HI}
		48	40.00^{FG}	43.00^{HIJ}	16.92^{GHI}	18.34^{IJK}	3810.00^{CDE}	4006.67^{CD}	3166.02^{EF}	3271.87^{FG}
H.S.D. at 5 %		5.19	5.60	2.44	2.55	128.40	100.95	138.70	122.62	

test. Results showed that the wheat grain obtained from the above treatments had significant differences between the all levels of treatments in concerning the No. 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.

Potassium is essential in nearly all processes needed to sustain plant growth and reproduction. Plants deficient in potassium are less resistant drought, excess water and high and low temperature. They are also less resistant to pests, diseases and nematode attacks. Because potassium improves the over all health of growing plants and helps them fight against disease it is known as the (quality) nutrient. Potassium affects quality factors such as size, shape, color and vigor of the seed or grain and improves the fiber quality of cotton [85]. The K content in plants varies from species to species. Potassium improves the plants disease resistance and stress tolerance and improves resistance to external abiotic stress [85].

CONCLUSION

From the obtained results of this study it could be concluded that Sakha 95 variety with fertilizing by 30 kg P_2O_5 and 48 kg K_2O fed^{-1} achieved maximum wheat grain yield fed^{-1} under the condition of El-Balasy village, Sidi Salem Directorate, Kafr El-Sheikh Governorate, Egypt.

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