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IMPACT OF NPK FERTILIZATION AND WILD MUSTARD (*Brassica napus* L) DENSITIES ON NUTRIENT UPTAKE AND WHEAT CROP

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ABSTRACT
Managing crop fertilization may be an important component of integrated weed management systems that protects crop yield and reduces the weed population over time.So, two field experiments were conducted at Shandaweel Research Station, Sohag Governorate during two growing winter seasons 2016/2017 and 2017/2018. The aim of this work was to study the effect of NPK fertilizer rates and wild mustard competition on wheat productivity. The experiment was laid out in a split-plot design with four replicatesand including eighteen treatments which were the combinations of three NPK fertilizer rates being 50 kg N-10 kg P2O5 -12 kg K2O fed-1, 75 kg N-15 kg P2O5 -24 kg K2O fed-1and 100 kg N-20 kg P2O5 -36 kg K2O fed-1 and six of wild mustard densities i.e., zero, 5, 10, 15, 20 and 25 plant m-2.

Results revealed that increasing NPK rates increased significantly the studied wheat yield and its components in both seasons. Application of N75P15K24and N100P20K36 fertilizer rates increased grain yield by 6.50 and 19.61 %respectively,in the firstseason and 3.89 and 11.56 %, respectively in the second season compared to the lowest (N50P10K12) fertilizer rate.

Also, increasing NPK fertilizer rates had a significant effect on N, P and K % of both wheat and wild mustard plants at 30, 60 and 90 days after sowing (DAS). N, P and K % decreased with growth in both wheat and wild mustard plants and were higher with wild mustard than wheat in Nand P showing that wild mustard plants area great competitor with wheat plants for N and P nutrients. Moreover, the addition of NPK fertilizer rates significantly affected N, P and K %, NPK uptake and protein % in wheat grain. Application of N75P15K24 and N100P20K36augmented protein % in grain wheat by 12.30 and 14.18 %, respectively in the first season and 9.13 and 10.75 %, respectively in the second season compared to the lowest (N50P10K12)fertilizer rate.

On contrary, increasing wild mustard density m-2 caused an adverse effect on wheat yield and its components in both seasons. The increasing number of wild mustardplants from 5 to 25 m-2 reduced the grain yield by 0.05 to 3.61 %, in the first season and by 3.12 to 10.29 %, in the second season compared with wild mustard free treatment.

Positive significant effects were detected for wild mustard density m-2 on N, P andK percentage of both wheat and wild mustard plants at 30, 60 and 90 days after sowing as well as wheat grain contents of N, P, K and protein in both seasons. Increasingwild mustard plants from 5 to 25 m-2decreased grain protein % from1.11 to 7.91 %, in 2016/17 and from 0.78 to 4.0 %, in 2017/18 compared with wild mustard free plots.From this study,we can conclude that the integration betweenN100P20K36fertilization and zero wild mustard plants m-2 gave thehighest wheat grain yield and protein.

INTRODUCTION

Wheat (*TriticumaestivumL*.) is the most important cereal crop in the world and the main food crop in Egypt where a great gap between consumption and production exists. Augmentingwheat production could be possible via both horizontal expansions through increasing the cultivated area with wheat and vertical expansion through the development of new cultivars having the high potentiality and subsequently implementing the proper cultural

practices as NPK fertilization and weed management especially wild mustard in the infested soils.

Wild mustard (***Sinapisarvensis L***.) is a serious weed in wheat and it reduced the grain and biomass yield by 76%.Wild mustard was described as a vigorously growing weed with a capability to attain greater height, establish and develop extensive leaf 1 area and horizontal branches when moisture and nutrients are not limiting. These morphological and physiological characteristics of wild mustard allowthe weed to shade and suppress the growth of its neighbors to a level that causes yield reduction **Fay (1990)**. **Behdarvand *et al.*, (2013)** revealed that yield and yield components of wheat were decreased with increasing wild mustard density. The density of 5, 10 and 15 wild mustard plants m^{-2} reduced the grain yield of wheat by 21.4, 32.2 and 40.2% respectively as compared to control.

On the other hand, fertilizer plays an important role in increasing wheat grain yield. The proper amount of NPK fertilizer application is considered a key to the large crop production **(Jan *et al.*,2007)**.Nitrogen is one of the most important nutrients which can change the competition ability of weeds and crops. Nitrogen increased the growth and production of wheat through increasing leaf area and photosynthetic efficiency of leaves; moreover, it has effects on increasing spike numbers in a unit area. With extending semi-dwarf cultivars which are more resistant to lodging, the demand for using fertilizer, especially nitrogen has been increased. As more was fertilizer is used, the yield of these cultivars increased (**Callaway, 1995**). **Mohajeri and Ghadiri (2003)** reported that the density of wild mustard more than 20 plants m^{-2} significantly decreased the grain yield of wheat under application of zero and 50 kg N ha^{-1}, while at the levels of 100, 150 and 200 $KgNha^{-1}$, increasing wild mustard density more than 10 plants per m^{-2} significantly decreased the wheat grain yield. **Delaney and Van Aker (2005)** showed that competition strength of weed with crop increases with the consumption of nitrogen fertilizer. **Barker *et al.*, (2006**) found that increased nitrogen leads to increase interference and competition ability of weeds with crops.**Naseri*et al.*, (2010)** found that wheat height was significantly affected by the increasing amount of soil nitrogen. Among the N concentrations (0, 80, 160 and 240 $kgha^{-1}$), the highest plant height (125.7 cm) was obtained in treatment with an application of 240 kg ha^{-1} while the lowest plant height (83.4 cm) was observed in unfertilized treatment. **Laghari*et al.*, (2010)** reported that fertilizer application significantly enhanced growth, yield and nutrient uptake traits of wheat. Application of 120 - 60 - 60 NPK kg ha^{-1} recorded maximum tillers, spike length, grains $spike^{-1}$, biological yield, grain yield, dry matter, leaf area index, crop growth rate and NPK uptake. **Malghani *et al.*, (2010)** concluded that the highest grain yield Kg ha^{-1} was recorded with the application of 175-150-125 NPK Kg ha^{-1}. The increase in yield was 51.58% higher as compared to control, where no fertilizer was used. Behdarvand ***et al.*, (2013)** indicated thatincreasing the nitrogen level increased the grain yield of wheat in weed-free plots, while in the presence of wild mustard; increasing nitrogen leveled to increasingthe competitive ability of wild mustard and increased the yield losses of wheat. The density of 15 wild mustard plants m^{-2} had decreased the grain yield of wheat by 31.6, 34.4 and 53.3 % under 90, 150 and 210 kg N ha^{-1} respectively.**Yousse*et al.*, (2013)** revealed that yield and its components were significantly affected by graded applied and splitting of N levels. The protein content in wheat grains was increased with increasing N levels up to 288 kg N ha^{-1} in presence of 53 kg P_2O_5 ha^{-1} as well as 120 kg K_2O ha^{-1}. **Ullah *et al.*, (2018)**concluded that the highest values of 1000grain weight and grain yield were recorded with the application 145-62-84 NPK $kgha^{-1}$.

Thus, the aim of this work is to investigate the effect of wild mustard densities on wheat yield productivity under NPK fertilization in the Sohag Governorate.

MATERIALS AND METHODS

Two field experiments were conducted in heavily and naturally infested soil with wild mustard (*Brassica* spp.) at Shandaweel Agricultural Research Station, Agricultural Research Center, Sohag Governorate in the two successive seasons 2016/17 and 2017/18. This experiment aimed to study the effect of wild mustard densities on wheat growth and yield productivity under NPK fertilization. Soil analysis of the experimental plots in both seasons is

shown in (Table 1) according to the procedures by **Jackson, (1973)**.

Table 1. Physical and chemical properties of the experimental soil in 2016/17 and 2017/18 seasons.

Soil characteristics		Growing seasons	
		2016/17	**2017/18**
Particle size distribution %	Sand %	27.50	28.44
	Silt%	35.3	33.20
	Clay%	37.2	38.36
	Textural class	**clay loam**	**clay loam**
Soil chemical properties	pH(1:2.5, soil: water suspension	7.60	7.70
	Ca CO_3%	3.60	3.60
	Organic matter %	1.45	1.60
	EC (dS m^{-1}soil paste extract)	1.12	1.16
	Soluble cations (Soil paste m mol_c L^{-1})		
	Ca^{2+}	3.38	2.60
	Mg^{2+}	1.48	1.20
	Na^{+}	6.31	7.72
	K^{+}	0.03	0.08
	Soluble anions (Soil paste m mol_c L^{-1})		
	CO_3^{2-}	-	-
	H CO_3^{-}	1.53	1.80
	Cl^{-}	7.20	7.30
	SO_4^{2-}	2.47	2.50
Nutrients status	**Available macronutrients (mg Kg^{-1})**		
	N	43.00	41.00
	P_2O_5	4.85	5.57
	K_2O	199.40	246.80

In this study, variety sids "12" (*Triticumasitivam*L.) was used and the preceding summer crop was sorghum (*Sorghum bicolor* (L)Moench) in both seasons. The sowing dates were 26th and 20nd of November in the first and the second seasons, respectively. The other normal agricultural practices of wheat growing in the region were done. The seeding rate was 60 kg fed^{-1} of variety sids 12 with *After drill* method (dry method). The experiment was laid out in split-plot arrangement with four replications.The plot area was 4 m^2 (2.0 m x 2.0 m).Each experiment included eighteen treatments,which were the combination of three rates NPK of fertilizers added in the main plots and six wild mustard densities allocated in subplots as follows.

A. The main plots included the following levels of NPK fertilizer:

1- **$N_{50}P_{10}K_{12}$**: (50 kg N + 10 kg P_2O_5 + 12 kg K_2O $feddan^{-1}$).

2- **$N_{75}P_{15}K_{24}$**: (75 kg N +15 kg P_2O_5 + 24 kg K_2O $feddan^{-1}$).

3- **$N_{100}P_{20}K_{36}$**: (100 kg N+20 kg P_2O_5 + 36 kg K_2O $feddan^{-1}$).

Phosphorus and potassium fertilization were added as calcium superphosphate (15.0% P_2O_5) and potassium sulphate (48.0% K_2O), respectively, during land preparation before planting. Meanwhile, nitrogen fertilizer was added in the form of urea (46.0 % N) in two doses where 40 % nitrogen fertilizer was broadcasted uniformly at the sowing and the rest of the amount (60 %) was added immediately before first irrigation.

B- The subplots included six wild mustard densities namely:

1- **Zero** wild mustard plantsm^{-2}(wild mustard free).

2- **5** wild mustard plants m^{-2}.

3- **10** wild mustard plants m^{-2}.

4- **15** wild mustard plants m^{-2}.

5- **20**wild mustard plants m^{-2}.

6-**25** wild mustard plants m^{-2} (as maximum natural infestation level in the experimental field).

After twenty days from sowing, annual broad-leaved, grassy weeds and zero wild mustard had been removed by hand-pulling biweekly intervals.

Data recorded:

A-Yield and yield components:

At harvest, ten guarded wheat plants were hand-pulled randomly from each plot to estimate the number of spikes m^{-2}, number of grains $spike^{-1}$, the weight of grains $spike^{-1}$ (g), 1000- grain weight (g) and all plants of the whole plot were harvested to estimate the grain yield (ard fed^{-1}).

B- Chemical analyses:

At 30, 60 and 90 days after sowing, two plants from wild mustard and wheat were chosen randomly from each plot and oven-dried at 70 °C overnight to determine nitrogen, phosphorus and potassium % in dry matter of wheat and wild mustard plants.

At harvest, grain samples were also dried in a forced oven at 70 °C, and all samples were then ground and wet digested using concentrated sulfuric acid and mixture of H_2SO_4 and perchloric acids (1:1) for oxidation **(A.O.A.C. 1990)** to the determined nutrient concentration. Total nitrogen was determined using the standard procedure of micro- Kjeldhal method as described by **Black, (1965).** Crud protein percent in wheat grains was calculated by multiplying the total nitrogen in a wheat meal by 5.7 according to **Tkachuk, (1966).** Phosphorus (%) was determined colourieterically according to **(Jackson 1973).** Potassium (%) was determined by flame photometer as described by **Jackson(1973).** NPK taken up in wheat grains was calculated by multiplyingNPK concentration by dry wheat of grain yield $feddan^{-1}$.

Statistical Analysis:

Statistical analysis was carried out according to **Gomez and Gomez (1984)** using MSTAT-C computer software **(Freed *et al.*, 1989)**. The means values were compared at 5 % level of significance by using L.S.D test. For regression study data were plotted and regression analyses were conducted. Linear$\tilde{y} = a + bx$, quadratic $\tilde{y} = a + bx\text{-}cx^2$and logstic$\tilde{y} = a + bx+cx^2+dx^3$models were estimated to describe the relationship between the measured dependent variable wild mustard density (no. m^{-2}) and independent variables wheat grain yield (ard fed^{-1}). Whereas, $\tilde{y}$ = variables, X= wild mustarddensity, a, b, c and d parameters represent intercept and slope of the regression of variables and regression model. The suitable model which fitted for prediction between mentioned above variables quadratic regression analysis according to **Snedecor and Cochran, (1989)** which is the correlation coefficient (R^2) was greater than other studied models and standard estimate error (SE) were smaller than those of the models.

RESULTS AND DISCUSSION

Yield and yield components:

Effect of NPK fertilizer rates.

Data in Table 2 illustrated that increasing N,P and K rates significantly improvedwheat grain yield and its componentsduring the two growingseasons.Both $N_{75}P_{15}K_{24}$and $N_{100}P_{20}K_{36}$ induced significant increase over the low rate ($N_{50}P_{10}K_{12}$) in favor of the highest rate which gave 28.69 and 34.61% increase in a number ofspike m^{-2},15.82 and 12.42% in a number of grain $spike^{-1}$, 38.58 and 32.13% in weight of grainsspike^{-1}and 4.6 and 7.8% in 1000-grain weight during the first and second seasons respectively.The same trend was noted with grain yield which was significantly increased by 6.50 and 19.61 % over the low rate due to$N_{75}P_{15}K_{24}$and$N_{100}P_{20}K_{36}$, respectively in the first season and 3.89 and 11.56 %, respectively in the second season. It is clear that the previous increases were due to raising NPK fertilizers which increased the number of spikesm^{-2}, No. of grainsspike^{-1}, grain weightspike^{-1}, 1000-grain weight and grain yield $feddan^{-1}$.**Zimdahl (2007)** found that the rise in fertilizer consumption especially nitrogen increasescrop yield and improvescrop compatibility with the weeds. However, the addition of nutrient elements influenced the weed growth more than the crop when weed density is high. These results are in line with**Laghari *et al.*, (2010),Malghani *et al.*, (2010),Youssef *et al.*, (2013), Fakkar *et al.*, (2016)and Litke *et al.*, (2018)**

Table 2 Effect of NPK fertilizerrates and wild mustard densities m^{-2} on yield and yield component of wheat in2016/017 and2017/018 seasons.

Treatments	No. of spikes m^{-2}	No. of grains $Spike^{-1}$	Grainsweight $Spike^{-1}$ (g)	1000- Grain weight (g)	Grain yield ($ardfed^{-1}$)
			2016/017 season		
A- NPK fertilizer					
$N_{50}P_{10}K_{12}$	365.63	45.51	3.37	46.33	17.54
$N_{75}P_{15}K_{24}$	451.14	47.29	3.78	48.07	18.68
$N_{100}P_{20}K_{36}$	470.52	52.71	4.67	48.46	20.98
L.S.D at $_{0.05}$	4.92	0.51	0.18	0.67	0.28
B- wild mustarddensities m^{-2}					
Zero	450.56	50.33	4.40	48.67	19.39
5	444.66	49.24	4.18	48.02	19.38
10	433.94	48.97	3.97	48.03	19.37
15	421.22	48.00	3.88	47.33	18.86
20	416.39	47.67	3.66	47.03	18.72
25	407.82	46.79	3.57	46.63	18.69
L.S.D at $_{0.05}$	11.34	1.10	0.21	0.52	0.43
			7/018 season		
A- NPK fertilizer					
$N_{50}P_{10}K_{12}$	363.61	4		47.82	19.55
$N_{75}P_{15}K_{24}$	455.79	48.61	3.98	49.17	20.31
$N_{100}P_{20}K_{36}$	489.44	52.88	4.77	51.55	21.81
L.S.D at $_{0.05}$	6.18	0.11	0.40	1.02	0.30
B- wild mustarddensities m^{-2}					
Zero	463.76	51.19	4.79	51.44	21.77
5	453.51	50.56	4.53	50.99	21.09
10	437.42	49.82	4.31	49.82	20.64
15	427.89	49.18	3.97	49.17	20.17
20	421.59	48.22	3.67	48.28	20.13
25	413.51	48.11	3.44	47.37	19.53
L.S.D at $_{0.05}$	16.86	0.29	0.41	1.45	0.72
Interactions					
A × B $_{2016/17}$	NS	NS	NS	NS	NS
A × B $_{2017/18}$	NS	NS	NS	NS	NS

Effect of wild mustard density:

Data in Table 2 showed that the number of spikes m^{-2}, number of grains $spike^{-1}$, grain weight $spike^{-1}$, 1000- grain weight and grain yield ($ard.fed^{-1}$) were significantly affected by wild mustard densities m^{-2}in both seasons. These parameters were progressively reduced by increasing wild mustard density during the two growing seasons. The highest wild mustard density (25 plants m^{-2}) recorded the highest reduction in a number of spikes m^{-2} by 9.49 and 10.84 %, a number of grains $spike^{-1}$ by 7.0 and 6.0 %, grains weight $spike^{-1}$ by 18.86 and 28.18 % and 1000- grain weight by 4.19 and 7.91 % during the first and second seasons, respectively compared with weed-freetreatment which gave the highest values for these yield components.Meantime increasing wild mustarddensityled to decreasing wheat grain yield. Inthe first season, less reduction in wheat grain yield recorded due to the densities of 5, 10, 15, 20 and 25 wild mustardplants m^{-2}which reduced grain yield by 0.05, 0.10, 2.73, 3.46 and 3.61 % as compared to zero density of wild mustard, respectively. A similar trend was obtained in the second season sincethe previousdecreasedwheatgrain yieldby3.12, 5.19, 7.35, 7.53 and 10.29 %, respectively.It is clear from the previous results that wheat grain yield was sharply affected by wild mustardinfestation since increasing wild mustardinfestation caused dramatic reduction in wheat yield $feddan^{-1}$. This is due to the decrease in the number of spikes m^{-2}, the number of grains $spike^{-1}$, grain weight $spike^{-1}$ and 1000-grain weight. These results were in harmony with those obtained by **Behdarvand *et al.*,(2013).**

Effect of the interaction between NPK fertilizer rates x wild mustard densities on yield and yield component.

Data in Table 2 indicated that the interaction between the two studied factorshad no significant effect onyield and its componentsin both seasons.

NPK concentration and uptake:

NPK concentration of wheat and wild mustard plants:

Effect of NPK fertilizer rates.

Generally, N, P and K concentrations in wheat and P % in wild mustard plants declined by age showing the transformation of the metabolized materials from the shoot to storage organs. Also, observed for N and K concentrationsin wild mustard plant increased from periods 30 until 60 DAS and declined during the late growth period 90 DAS. During the three studied growth periods,N and P concentrationsin wild mustard plants werehigher than that of wheat plants. Meanwhile,the same trend of N and P concentrationswas also observed for K concentrationduring the twogrowth periods of 60 & 90DASonly, butthe firstgrowth period (30DAS)K concentrationof wheat plantwas higherthan that ofthe wild mustard plant.

Data presented in Table 3 demonstrated that NPK fertilizers had significantly effect on N, P and K % of wheat and wild mustard plants in various studied growth periods at 30, 60 and 90 DAS in bothseasons. Increasing NPK fertilizer rates from $N_{50}P_{10}K_{12}$ to $N_{100}P_{20}K_{36}$increased N, P and K % of wheat and wild mustard plants at different growth periods in both seasons. Application of$N_{100}P_{20}K_{36}$fertilizer gave the highest values of N, P and K % of wheat and wild mustard plants at the studied growth periods in both seasons compared to $N_{50}P_{10}K_{12}$fertilizer.

Effect of wild mustard density:

Data presented in Table 3 showed that wild mustard densities m^{-2} significantly affected N, P and K % of wheat and wild mustard plants at 30, 60 and 90 DAS in both seasons. The greatest values of N, P and K % in a wheat plant at 30, 60 and 90 DAS were observed from weed-free treatment and the lowest values was obtained from a density of 25 wild mustard plants m^{-2} in both seasons. While, the maximum N, P and K % in wild mustard at 30, 60 and 90 DAS were obtained from a density of 5 wild mustard plants m^{-2} and the lowest values wereobserved from a density of 25 wild mustard plants m^{-2} in both seasons.

Effect of the interaction between NPK fertilizer rates x wild mustard densities onthe **nutrient concentration of wheat and wild mustard plants:**

There was no significant effect onthe interaction between NPK fertilizer rates and wild mustard densities on NPK concentration of wheat and wild mustard plantsat different growthperiods inboth seasons as shown in Table 3.

NPK concentration and uptake in wheat grain:

Effect of NPK fertilizer rates.

Data in Table 4 appeared significant increases in N, P and K uptake, as well as protein % in wheat grains, were noticed by increasing NPK rate to $N_{75}P_{15}K_{24}$ and$N_{100}P_{20}K_{36}$ in favour of the higher rate which gavesignificant incrementin N, P & K uptakeandprotein %by 26.76, 69.44, 80.72and14.18%respectively,in the firstseasonand by 23.44, 43.78, 46.35 and10.72 %respectively,in the second season.There were significant differences between $N_{75}P_{15}K_{24}$ and $N_{100}P_{20}K_{36}$in all cases. Worth mentioning the N, P and K percentages in wheat grain followed the same trend observed with N, P and K uptake andprotein %.In this regard, **El- Kouny, (2007)** indicated that increased mineral fertilizer significantly increased crude protein, phosphorus and potassium percentage in wheat grain. **Fakkar *et al*., (2016)** reported that grain protein content and N,P and K% and uptake increased with increasing fertilizer rates. These results are in line with **Laghari *et al*., (2010),Youssef *et al*.,(2013)**

Effect of wild mustard density:

As shown in Table 4 N, P and K percentages or uptake, as well as grain protein percentage, were reduced by increasing wild oat density and the highest density (25 wild oat plants m^{-2}) recorded the highest reduction by 8.56, 33.49 and 18.91 % for N, P and K%,respectively compared with weed-free treatment in the first seasonand by 4.02, 21.22 and 27.26 %, respectively in the second season. The corresponding values for N, P and K uptake were 11.69, 20.60 and 22.51%, respectivelyin the first season and 13.83, 24.83 and 29.82 %, respectivelyin the second season. The proteincontent of wheat grain took the same trend since the highest wild oatdensity (25plants m^{-2}) reduced it by 7.91 and 4.0 % during the first and second seasons,respectively compared with zero wild oat plants m^{-2}.These results suggest that wild mustard compete strongly with the wheat crops for main macronutrients especially with nitrogen and phosphorus. Similar results were obtained by **Fakkar *et al*., (2016).**

Effect of the interaction between NPK fertilizer rates x wild mustard densities onN, P&K % and uptake as well as protein in wheat grains

The obtained data in Table 4 also reveal thatthisinteraction hadnot significanteffects on N, P&K % and uptake as well as proteinin wheat grainsin both seasons.

Table 3 Effect of NPK fertilizer rates and wild mustard densities on nutrient concentration and uptake by grain wheat in 2016/ 17 and 2017/ 18 seasons.

Treatments	Nutrient content (%)			Nutrient uptake (kg fed^{-1})			Protein %
	N	P	K	N	P	K	
				2016/17 season			
A- NPK fertilizer							
$N_{50}P_{10}K_{12}$	1.96	0.347	0.348	51.46	9.13	9.18	11.14
$N_{75}P_{15}K_{24}$	2.19	0.419	0.472	61.51	11.76	13.25	12.51
$N_{100}P_{20}K_{36}$	2.23	0.491	0.527	65.23	15.47	16.59	12.72
L.S.D. at $_{0.05}$	0.06	0.01	0.01	0.86	0.24	0.33	0.30
B- Wild mustard densities m^{-2}							
zero	2.22	0.415	0.439	64.69	13.25	14.44	12.64
5	2.19	0.382	0.411	63.99	13.15	14.14	12.50
10	2.15	0.359	0.390	62.88	12.70	13.49	12.29
15	2.12	0.320	0.379	60.23	11.87	12.69	12.10
20	2.04	0.309	0.369	57.48	11.23	12.07	11.57
25	2.03	0.276	0.356	57.13	10.52	11.19	11.64
L.S.D. at $_{0.05}$	0.09	0.02	0.01	3.52	0.43	0.75	0.52
				2017/18 season			
A- NPK fertilizer							
$N_{50}P_{10}K_{12}$	2.06	0.372	0.391	60.33	10.94	11.50	11.72
$N_{75}P_{15}K_{24}$	2.24	0.418	0.494	68.40	12.76	15.04	12.79
$N_{100}P_{20}K_{36}$	2.28	0.480	0.513	74.47	15.73	16.83	12.98
L.S.D. at $_{0.05}$	0.02	0.01	0.01	1.30	0.17	0.30	0.07
B- Wild mustard densities m^{-2}							
zero	2.24	0.443	0.521	73.16	15.06	16.90	12.75
5	2.22	0.468	0.454	70.30	14.31	16.16	12.65
10	2.20	0.409	0.476	68.28	13.56	14.99	12.55
15	2.18	0.395	0.428	66.26	12.57	13.87	12.46
20	2.16	0.369	0.415	65.38	12.05	13.00	12.32
25	2.15	0.349	0.379	63.04	11.32	11.86	12.24
L.S.D. at $_{0.05}$	0.02	0.05	0.08	2.30	0.65	0.62	0.12

Interactions							
A × B $_{2016/17}$	NS	NS	NS	NS	NS	NS	NS
A × B $_{2017/18}$	NS	NS	NS	NS	NS	NS	NS

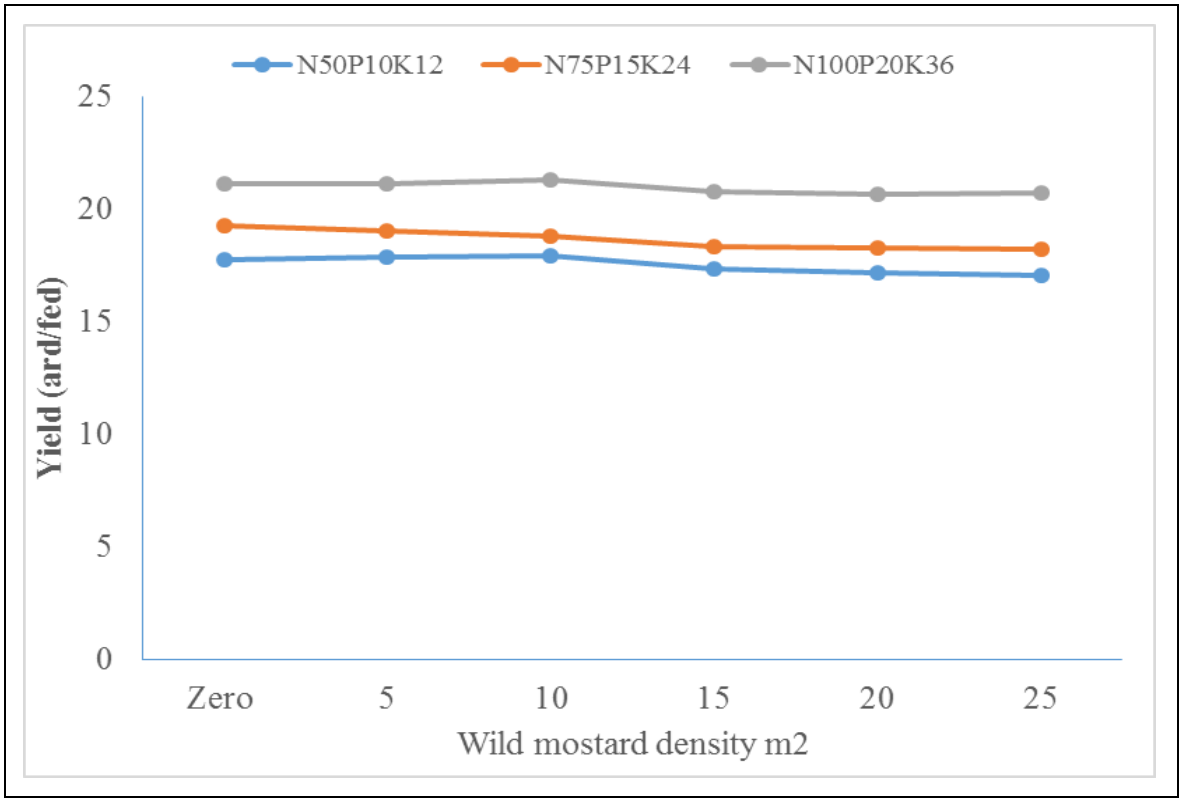
Table 4 Effect of interaction between NPK fertilizer rates and wild mustard densitieson observed and predicted yield and yield losses of wheat in 2016/2017and 2017/2018 seasons.

Treatments		2016/17 season			2017/18 season		
NPK fertilizers	Wild mustard densities (plants m^{-2})	Observed grain yield ard.fed^{-1}	Predicted grain yield ard.fed^{-1}	Yield losses %	Observed grain yield ard.fed^{-1}	Predicted Grain yield (ard.fed^{-1})	Yield losses %
$N_{50}P_{10}K_{12}$	Zero	17.97	17.86	0.0	20.70	20.70	0.0
	5	17.90	17.83	0.4	20.23	20.13	2.3
	10	17.77	17.70	1.1	19.70	19.53	4.8
	15	17.37	17.27	3.3	19.37	18.94	6.4
	20	17.17	17.14	4.5	18.83	18.34	9.0
	25	17.07	17.00	5.0	18.47	17.75	10.8
$N_{75}P_{15}K_{24}$	Zero	19.27	19.23	0.0	21.73	21.73	0.0
	5	19.07	18.97	1.1	20.97	20.95	3.5
	10	18.83	18.61	2.3	20.43	20.17	6.0
	15	18.36	18.25	4.7	19.83	18.94	8.7
	20	18.30	17.89	5.0	19.60	18.61	9.8
	25	18.26	17.53	5.2	19.30	17.83	11.2
$N_{100}P_{20}K_{36}$	Zero	21.30	21.19	0.0	22.87	22.69	0.0
	5	21.16	21.00	0.7	22.07	22.01	3.5
	10	21.13	20.96	0.8	21.83	21.63	4.5
	15	20.83	20.65	2.2	21.80	21.55	4.7
	20	20.73	20.43	2.7	21.43	21.17	6.3
	25	20.70	20.12	2.8	20.83	20.70	8.9
L.S.D. at $_{0.05}$		ns	--	--	ns	--	--

5- Predictionof wheat grain yield losses due to wild oatcompetition

It was clear that the suitable model which fitted for prediction wheat grain yield (ard. fed.$^{-1}$) losses and wild mustard densitieswas quadratic regression because the correlationcoefficient (R^2) was greater than other studied models and standard estimateerror (SE) were smaller than those of the polynomial models were: $\hat{Y} = 17.86 - 0.004 x + 0.002 x^2$ $R^2 = 0.510$, $\hat{Y} = 19.33 - 0.071 x + 0.001 x^2$ $R^2 = 0.625$and $\hat{Y} = 21.19 - 0.003 x + 0.000 x^2$ $R^2 = 0.269$)due to the increasing wild mustard densities from zero to 25 plants m^{-2}under $N_{50}P_{10}K_{12}$, $N_{75}P_{15}K_{24}$ and $N_{100}P_{20}K_{36}$, respectively in the first season and $\hat{Y} = 20.72 - 0.12 x + 0.001 x^2$ - $R^2 = 0.677$, $\hat{Y} = 21.73 - 0.159 x + 0.003 x^2$, $R^2 = 0.819$ and $\hat{Y} = 22.69 - 0.076 x + 0.000 x^2$ - $R^2 = 0.497$ under $N_{50}P_{10}K_{12}$,$N_{75}P_{15}K_{24}$ and $N_{100}P_{20}K_{36}$, respectively in the second season.

The regression of wheatgrain yield on wild mustard densities across the different NPK fertilizers (Table 4 and Figure 1) showed that grain yields and wild mustard density had a strong negative association. An increase in wild mustard density caused a significant reduction in grain yield.



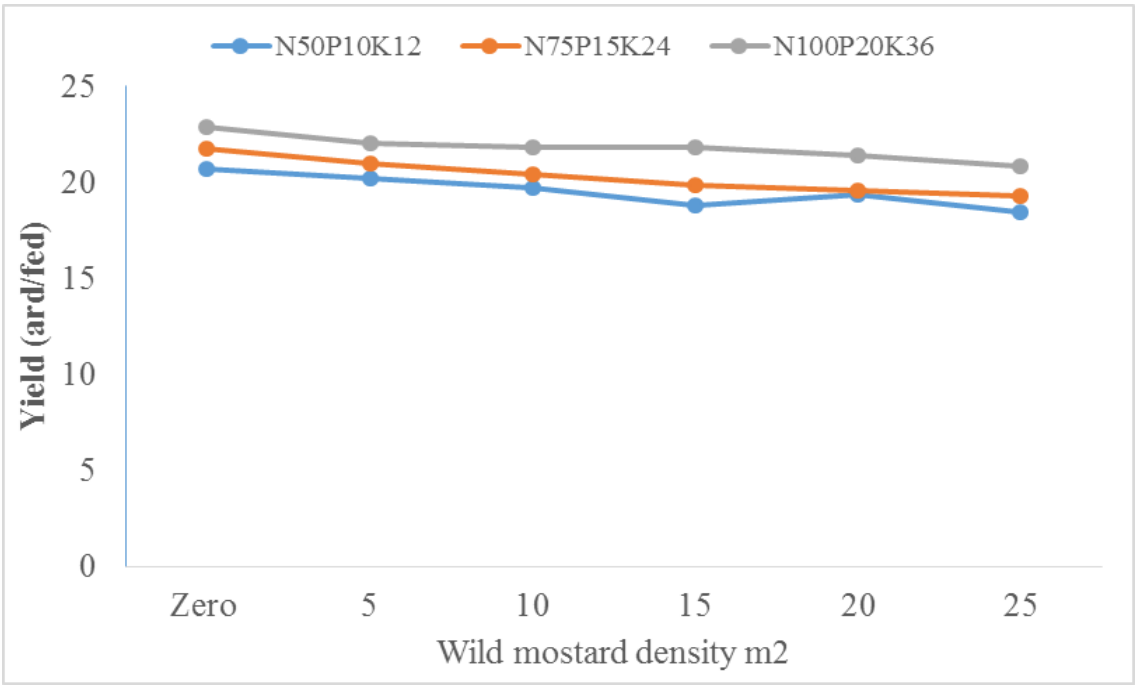


Fig. 1. Relationship between wild mustard density m^{-2} and wheat grain yield ($ard.fed^{-1}$) under three NPK fertilizers.

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