Effect of Seed Inculcation, Phosphorus and Potassium Fertilization Levels on Germination Parameters of Mung Bean

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Abstract

To improve mungbean germination boundaries, this examination intended to concentrate on the exhibition of Kawmy1 cultivar to various portions of seed treatment, phosphorus and potassium fertilizers. Consequently, a lab test was completed after the field exploration in each season under the Seed Testing lab states of Central Administration for Seed Testing and Certification, Ministry of Agriculture, Egypt. With three replications, the experiment was carried out in a split-split plot design. Seed inoculation was taking place on the major plots. The levels of phosphorus fertilizer were divided into sub-plots. The potassium fertilization levels were arranged in the sub-sub-plots. The results indicated that the highest germination percentage values and velocity coefficient were obtained from seed inoculation in the first and second seasons, respectively. The increases in phosphorus fertilizer rates to 45 kg/fed produced the best germination rate, germination index, mean germination time, coefficient of velocity and value of the vigor in the first season. The increases in potassium fertilizer rates to 50 kg k/fed produced the best germination percentage, velocity coefficient and vigour value in the second season. It could be concluded that injection of mung bean seeds with Rhizobium and increasing phosphorus fertilizer to 45 kg P2O5/fed and potassium to 50 kg K2O/fed to enhance germination parameters.

Keyword: Mungbean, Rhizobium, phosphorus, potassium, germination.

تأثير التلقيح البكتيرى للبذور ومستويات التسميد الفوسفاتى والبوتاسي على صفات إنبات فول المانج

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المستخلص

أجري البحث في المعمل المركزى لفحص وإخبارات التقاوى – مركز البحوث الزراعية – وزارة الزراعة – مصر لدراسة صفات الإنبات لبذور نبات فول المانج صنف قومى 1 الناتج عن تأثير التلقيح البكتيرى ومستويات مختلفة من التسميد الفوسفاتى والبوتاسى، حيث تم زراعة تجربتين حقليتين خلال موسمي الزراعة الصيفيين المتتاليين لعامي 2018 و 2019 في حقل خاص في قرية الراكة ، مركز العياط ، الجيزة ، مصر. ثم إجراء التجارب الحقلية في تجربة عاملية فى تصميم القطع المنشقة مرتين في ثلاث مكرارات. تم تووزيع معاملتى التلقيح البكتيرى بجنس الريزوبيوم (تلقيح البذور بالريزوبيوم ، عدم تلقيح البذور) في القطع الرئيسية، بينما أحتلت مستويات التسميد الفوسفاتى (15 و 30 و 45 كجم P_2O_5/فدان) القطع الشقية، بينما أحتلت معاملات التسميد البوتاسى (0، 25، 50 كجم K_2O/فدان) القطع التحت شقية. أشارت النتائج المتحصل عليها أن أعلى القيم لكل من الصفات التاليه نسبة الإنبات ومعامل سرعة الإنبات تم الحصول عليها من تلقيح البذور على التوالي في الموسمين الأول والثاني. أدت الزيادات في معدلات الأسمدة الفوسفاتية إلى 45 كجم/فدان إلى الحصول على أفضل معدل إنبات ودليل الإنبات ومتوسط زمن الإنبات ومعامل سرعة الإنبات وقيمة القوة. كما أشارت النتائج إلى أن زيادة معدلات السماد البوتاسي إلى 50 كجم/فدان إلى الحصول على أفضل نسبة إنبات ومعامل سرعة إنبات وقيمة القوة في الموسم الثاني. يمكن الاستنتاج أن تلقيح بذور فول المانج ببكتريا جنس الريزوبيوم وزيادة السماد الفوسفاتى إلى 45 كجم P_2O_5/فدان والبوتاسيوم إلى 50 كجم/فدان إلى تحسين صفات الإنبات لبذور فول المانج صنف قومى 1 الناتج من محصول موسمى 2018 و 2019.

الكلمات المفتاحية: فول المانج، التلفيح ، الفوسفاتى والبوتاسى، الإنبات.

Introduction

Mungbean (*Vigna radiata* L.) is a significant palatable bean in the human eating regimen worldwide. Mungbean plant leaves and their deposits are utilized as creature feed. The yield is possibly valuable in improving trimming frameworks as a cover crop because of its fast development and early developing qualities. It can fix barometrical nitrogen through the advantageous interaction between the host mungbean and soil microscopic.

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Organisms and further develop soil fruitfulness. Mungbean contains 51% sugars, 26% protein, 4% minerals and 3% nutrients. From a nourishing perspective, mungbean is outstanding among beats (Khan, 1981 and Kaul, 1982).

Mungbean is a brief-length, herbaceous, yearly, self-pollinated vegetable heartbeat crop under the family. It can also fix air nitrogen in the soil, improving the dirt quality. Mung bean is filled in the spring and summer seasons and has less water necessities than other summer crops. Mungbean is dry season safe harvest and can make due under unfavourable circumstances and, in downpours, take care of plots (Anjum *et al.,* 2006). The use of rhizobium inoculation on mungbean (*Vigna radiata* L.) is uncommon, and available knowledge on the influence of rhizobium seed inoculation on mungbean yield and a few other vegetable yields, such as peanut (Abido and Omar, 2020), has been evaluated.

Phosphorus (P) fertiliser is a key macronutrient that ranks second only to nitrogen fertiliser in importance as a harvest supplement. Phosphorus is required for plant development, sugar and starch use, photosynthesis, cell division, and core organisation (Raghothama and Karthikeyan, 2005). Phosphorus molecules are linked to energy exchange and capacity within plants. Phosphate combinations like ATP and ADP store energy from photosynthesis and sugar digestion for later usage in development and proliferation (Marschner, 1995). A sufficient inventory of accessible P in soil is related to expanded root development, implying roots can investigate more soil for supplements and dampness. Phosphorus is a fundamental component for crops with enormously diminished take-up from an obsession with mineral particles like aluminium, iron, calcium and magnesium. This study may be used to prove that applied sciences are highly significant in life because of their various applications in the present and the past (Abido and Zsombik, 2018; Abido and Zsombik, 2019; Abido *et al.,* 2021).

So, this study aimed to see how seed inoculation, phosphate fertilisation, potassium fertilisation, and their interactions affected mungbean germination parameters in the El-Ayat Center, Giza Governorate, Egypt.

Materials and methods

During the two subsequent summer growing seasons of 2018 and 2019, two field tests were conducted at a private field in El-Rakah Village, El-Ayat Center, Giza, Egypt, to investigate the effects of mung bean seed inoculation, phosphorus and potassium fertilisation levels, and their interactions on germination characters.

Three replications were used for factorial experiments in the split-split plot design. The total number of experimental units was 54 unit. Seed inoculation treatments (seed inoculation with Rhizobium and seed un-inoculation) were utilized in the main plots, with 100 g inoculation per kg of fresh mung bean seeds. For 18-20 minutes, the seeds were dipped in the appropriate culture broth. Before sowing, the seeds were allowed to dry in the shade.

Phosphorus fertilizer levels, i.e., 15, 30 and 45 kg P_2O_5/fed, were arranged in the sub-plots and were added before sowing. The potassium fertilizer was added before the 2nd irrigation.

The three potassium fertilization levels (0, 25 and 50 kg K_2O/fed) were arranged in the sub-sub plots before the first irrigation (15 days from sowing). All rural practices were executed by the Ministry of Agriculture and Land Reclamation proposals. A lab try was completed after the field exploration in each season under the research facility states of the Egyptian Ministry of Agriculture's Central Administration for Seed Testing and Certification, which conducts seed testing. This investigation aimed to evaluate seed quality as a consequence of the field trial.

In sanitized Petri dishes, irregular examples of 400 seeds from each treatment were generated on top channel paper (14 cm width). Each Petri-dish housed 25 seeds, and four Petri-dishes were held near one another and brooded at 25^{o} C with 100 percent relative stickiness, with three replications used to assess each seed test performed on each treatment according to the standards of the International Seed Testing Association (ISTA, 1998).

Germination studied parameters

The number of seedlings that emerged at the first, second, third, and fourth counts are represented by N1, N2, N3, and N4, respectively, whereas Ti 1- germination percentage at the end (FG percent). The degree of seed sprouting as the accompanying condition in the 2014/2015 and 2017/2018 seasons was communicated by the level of seed sprouting typically following twelve days.:

$$\text{FG}\ \% = \frac{\text{Number of normal seedlings}}{\text{Number of total seeds}} \times 100$$

2- The germination rate: In the 2014/2015 and 2017/2018 seasons, it was determined that the conditions Bartlett (1937) represented were correct.

$$\text{Germination rate} = \frac{\mathbf{a+(a+b)+(a+b+c)+\ldots\ldots+(a+b+c+m)}}{\mathbf{n\,(a+b+c+\cdots\ldots+m)}}$$

Wherever a, b, c, and m signify the number of seedlings that appeared at the primary, second, third, and fourth counts, respectively, and m signifies the number of counts.

3- Germination index (GI). In the 2014/2015 and 2017/2018 seasons using Ellis and Roberts' (1981) equation:

$$\text{Germination index} = \frac{\mathbf{N_1+N_2+N_3+N_4}}{\mathbf{T_i}}$$

4- Germination time average (MGT). It was calculated in the 2014/2015 and 2017/2018 seasons using Ellis and Roberts' equation (1981):

$$\text{MGT} = \frac{\sum \text{Dn}}{\sum \text{n}}$$

Where (n) is the number of grains germinating on a given day, and D is the number of days since germination began.

5- The coefficient of speed (CV): A unit still up in the air by a numerical control that joins the number of seeds sprouted, and the rate of germination was determined utilizing the accompanying recipe:

C V= 100[∑Ni / ∑Ni Ti]

On the day I, N represents the number of fully grown seeds, and T represents the number of days from planting (Scott *et al.,* 1984). A higher CV value implies that the seed was generated with a faster germination period in general.

6- The value of the vigor (V): This is determined as a proportion of the germination rate because the upsides of this file mirror the germinative capacity of the seeds per unit of time (Bradbeer, 1988). The recipe utilized was:

V= (a/1 + b/2 + c/3 + d/4 + . . . + x/n) x 100 / S

Where a, b, c... refer to the number of seeds produced after 1, 2, 3,... long periods of imbibition, x is the seed amount for day n, and S is the total number of seeds sowed. The range of V characteristics is 0 to 100. (the highest rate). The accompanying scale was used to organize the levels:

- Exceptionally quick 33.33 < V < 100
- Quick 11.11 <V < 33.33
- Medium 5.0 < V < 11.11
- Slow 0.0 < V < 5.0

All acquired information was measurably dissected by the method of examination of fluctuation (ANOVA) for the split-split plot plan of each season as distributed by Gomez and Gomez (1984) by utilizing the method for "MSTAT-C" PC programming bundle. The least massive distinction (LSD) strategy was utilized to test the distinctions among treatment implies at a 5 % level of likelihood, as depicted by Snedecor and Cochran (1980).

Results and Discussion

A- Seed inoculation effects

The results indicated that the highest germination percentage, the velocity coefficient (86.37, 15.74), was obtained from seed inoculation in the first and second seasons. The beneficial effects of seed inoculation can improve phytohormone production and photosynthesis through osmoregulation, which enhances nutrient and water uptake and growth. Therefore, seed inoculation is a better option because it increases germination characteristics and reduces production costs and environmental hazards. These results agree with those detected by Hussain *et al.* (2016) and Navsare *et al.* (2018).

B- Phosphorus fertilization levels effects

According to the results reported in (Tables 1 and 2), phosphorus fertilization levels (15, 30, and 45 kg P/fed) they significantly impacted germination percentage, mean germination time, and velocity coefficient in the 2019 season. The maximum level of phosphorus fertilizer (45 kg P/fed) resulted in the highest germination and seedling character parameters. It indicates that mange bean plants reacted to up to 45 kg P/fed phosphorus fertilizer. Fertilizing mange bean plants with 30 kg P/fed came in second place, behind 45 kg P/fed, regarding the lowest difference between these traits, followed by fertilizing with 15 Kg P/fed. Increasing phosphorus fertilizer levels up to 45 kg p/fed produced the germination rate (0.570), germination index (13.28), mean germination time (3.16), the coefficient of velocity (16.72), highest values of the value of vigor (16.29) in the first seasons. These results agree with those detected by Kandil *et al.* (2017) and Kandil *et al.* (2019).

C- Potassium fertilizer levels effects

Means of germination percentage, the coefficient of velocity and the value of the vigor as affected by potassium fertilizer levels are significantly affected as presented in (Tables 1 and 2). Increasing potassium fertilizer levels from 25 and 50Kg k/fed significantly increased germination percentage, the coefficient of velocity and value of the vigor in the second season. Increasing potassium fertilizer levels up to 50 Kg k/fed produced the germination percentage (86.00), the coefficient of velocity (15.77), highest values of the value of the vigor (15.52) in the second seasons. These results agree with those detected by Hussain *et al.* (2016) and Navsare *et al.* (2018).

Table 1. Means of final germination percentage, germination rate and germination index as affected by the interaction among inoculation, phosphorus fertilizer levels and potassium fertilizer levels during the first and second seasons.

Treatments	Germination percentage		Germination rate		Germination index	
	2018	2019	2018	2019	2018	2019
A- Inoculation:						
Seed inoculation	86.37	84.07	0.553	0.519	12.65	11.93
Seed uninoculation	82.89	83.11	0.540	0.480	12.64	10.97
F. test	*	NS	NS	NS	NS	NS
B- Phosphorus fertilizer levels:						
15 kg P/fed	83.78	82.67	0.511	0.490	11.88	11.18
30 kg P/fed	84.78	83.22	0.558	0.503	12.77	11.50
45 kg P/fed	85.33	84.89	0.570	0.505	13.28	11.66
F. test	NS	NS	*	NS	*	NS
LSD at 5%	-	-	0.036	-	1.16	-
C- Potassium fertilizer levels:						
Without	83.44	82.11	0.543	0.495	12.31	11.26
25 kg K/fed	84.89	82.67	0.544	0.497	12.66	11.48
50 kg K/fed	85.56	86.00	0.553	0.507	12.97	11.60
F. test	NS	* *	NS	NS	NS	NS
LSD at 5%	-	2.34	-	-	-	-
D-Interaction (F-Test):						
A x B	*	*	NS	*	*	NS
A x C	NS	*	NS	NS	NS	*
B x C	*	*	*	NS	*	*
A x B x C	*	*	NS	NS	NS	*

Table 2. Means of germination time, coefficient of velocity and value of the vigor as affected by the interaction among inoculation, phosphorus fertilizer levels and potassium fertilizer levels during the first and second seasons.

Treatments	Means of germination time		coefficient of velocity		value of the vigor	
	2018	2019	2018	2019	2018	2019
A- Inoculation:						
Seed inoculation	3.29	3.41	16.21	15.74	16.04	15.14
Seed uninoculation	3.37	3.66	15.86	15.22	15.83	14.64
F. test	NS	NS	NS	*	NS	NS
B- Phosphorus fertilizer levels:						
15 kg P/fed	3.44	3.63	15.61	15.21	15.37	14.82
30 kg P/fed	3.27	3.49	16.18	15.62	16.09	14.84
45 kg P/fed	3.16	3.48	16.27	15.62	16.29	15.02
F. test	*	NS	*	NS	*	NS
LSD at 5%	0.18	-	0.41	-	0.60	-
C- Potassium fertilizer levels:						
Without	3.33	3.65	15.12	15.14	15.71	14.39
25 kg K/fed	3.29	3.53	15.98	15.54	15.89	14.77
50 kg K/fed	3.28	3.42	15.99	15.77	16.16	15.52
F. test	NS	NS	NS	*	NS	*
LSD at 5%	-	-	-	0.53	-	0.39
D-Interaction (F-Test):						
A x B	*	NS	*	NS	*	NS
A x C	NS	*	NS	NS	*	NS
B x C	*	NS	*	NS	*	*
A x B x C	NS	NS	NS	NS	NS	*

D- Interactions effects

D1. Interaction between seed inoculation and phosphorus fertilization levels effects:

Seed inoculation and phosphorus fertilization levels interaction significantly affected germination percentage in both seasons, germination rate in the 2019 season, germination index, mean germination time, coefficient of velocity and value of the vigor in the 2018 season as presented in (Tables 1 and 2). The influence of seed inoculation and phosphorus fertilization levels on germination % was graphically represented in (Figs. 1) for both seasons. The results clearly showed that seed inoculation genotype and addition of phosphorus fertilization at 45 kg P/fed recorded the highest values of germination percentage (88.78 and 86.67%) in the first and second seasons, respectively. The lowermost values from germination percentage were recorded from sown seed uninoculation Kawmy genotype (81.78 and 81.33%) when fertilized with the lowest phosphorus fertilization (15 kg/fed) in the first and second seasons, respectively.

The results graphically illustrated in (Figs.2) the interaction effect between seed inoculation and phosphorus fertilization levels on germination rate in the 2019 season. The results showed that seed inoculation genotype and addition of phosphorus fertilization at 45 kg P/fed recorded the highest values (0.537 %) of germination rate in 2019. The lowest values from the germination rate in the 2019 season were recorded from the sown seed uninoculation Kawmy genotype (0.443) when fertilized with the lowest phosphorus fertilization (15 kg/fed) in the 2019 season. The influence of seed inoculation and phosphorus fertilization levels on germination index was graphically demonstrated in (Figs.3) throughout the 2018 season. The results showed that seed inoculation genotype and addition of phosphorus fertilization at 45 kg P/fed recorded the highest values (13.56) of germination index in 2018.

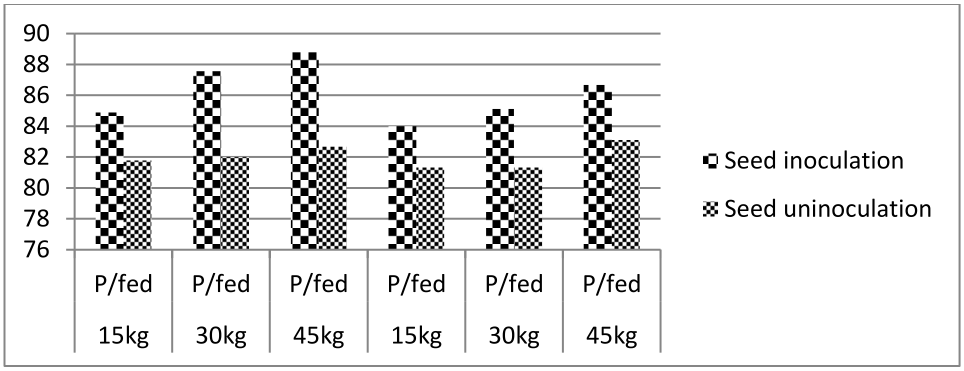

Figure 1. During the seasons 2018 and 2019, the interplay between seed inoculation and phosphorus fertilization levels impacted the mean germination percentage.

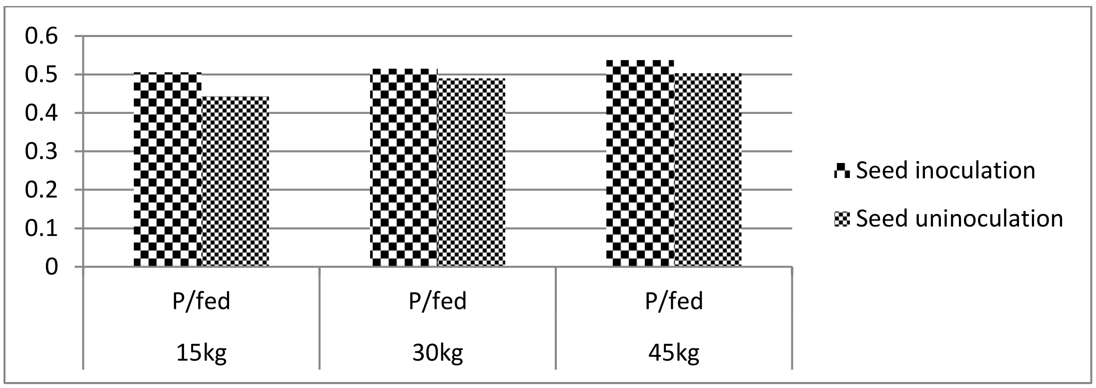

Figure 2. Means of germination rate as a function of seed inoculation and phosphorus fertilization levels during the 2019 growing season.

While the lowermost values from the germination index in the 2018 season were recorded from sown seed uninoculation Kawmy genotype (11.64) when fertilized with the lowest phosphorus fertilization (15 kg/fed) in 2018. The influence of seed inoculation and phosphorus fertilization levels on mean germination time was graphically represented in Figs.4 throughout the 2018 season. The results clearly showed that seed inoculation genotype and the addition of phosphorus fertilization at 45 kg P/fed recorded the lowest values (2.97) of mean germination time in the 2018 season. The highest values from mean germination time in 2018 were recorded from sown seed uninoculation Kawmy genotype (3.49) when fertilized with the lowest phosphorus fertilization (15 kg/fed) in 2018. The results graphically illustrated in Figs.5 the interaction effect between seed inoculation and phosphorus fertilization levels on the velocity coefficient in the 2018 season. The results clearly showed that seed inoculation genotype and addition of phosphorus fertilization at 45 kg P/fed recorded the highest values (16.65) of

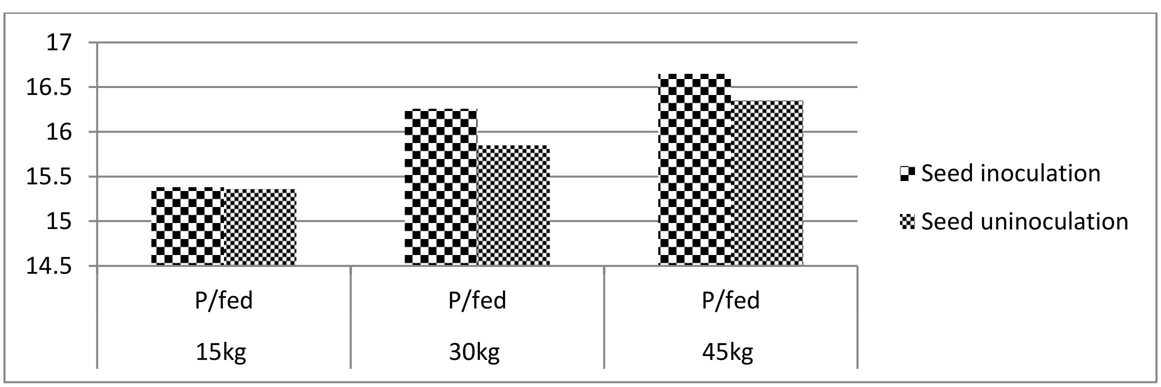

Figure 3. During the 2018 growing season, the interplay between seed inoculation and phosphorus fertilization levels altered the mean germination index.

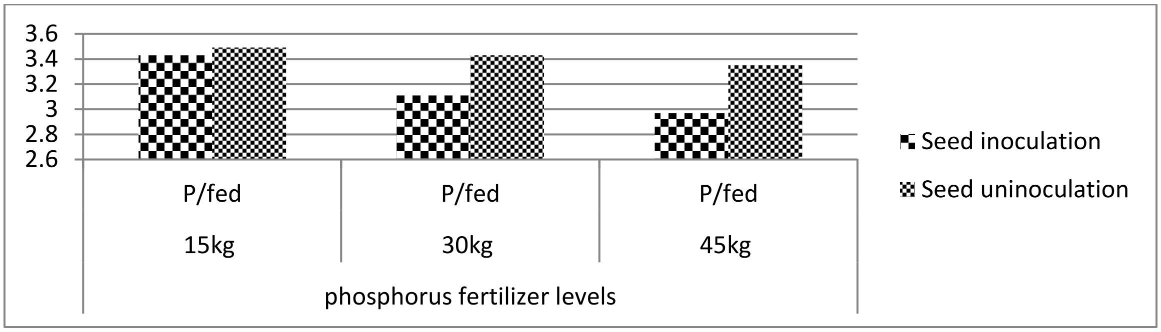

Figure 4. During the 2018 growing season, the interplay between seed inoculation and phosphorus fertilization levels altered the mean germination time.

Coefficient of velocity in the 2018 season. The lowermost values from the coefficient of rate in the 2018 season were recorded from sown seed uninoculation Kawmy 1 genotype (15.36) when fertilized with the lowest phosphorus fertilization (15 kg/fed) in the 2018 season. The results graphically illustrated in (Figs.6) the effect of the interaction between seed inoculation and phosphorus fertilization levels on the value of the vigor in the 2018 season. The results clearly showed that seed inoculation genotype and addition of phosphorus fertilization at 45 kg P/fed recorded the highest values (17.07) of the importance of vigor in the 2018 season. While the lowermost values from the value of the vigor in the 2018 season were recorded from sown seed uninoculation Kawmy genotype (15.18) when fertilized with the lowest phosphorus fertilization (15 kg/fed) in 2018.

D2. Interaction between seed inoculation and potassium fertilization levels effects: Seed inoculation and potassium fertilization levels interaction significantly affected germination percentage, germination index, mean germination time in 2019 season and value of the vigor in 2018 season as presented in (Tables 1 and 2). The influence of seed inoculation and potassium fertilization levels on germination % was graphically represented in (Figs.7) for the 2019 season. The results clearly showed that seed inoculation genotype and addition of potassium fertilization at 50 kg k/fed recorded the highest values (88.00) of germination percentage in 2019 season. While the lowermost values from germination percentage in 2019 season was recorded from sown seed uninoculation Kawmy genotype (79.78) when without the potassium fertilization in 2019 season. The influence of seed inoculation and potassium fertilization levels on germination index in the 2019 season is graphically represented in (Figures 8 and 9). The results clearly.

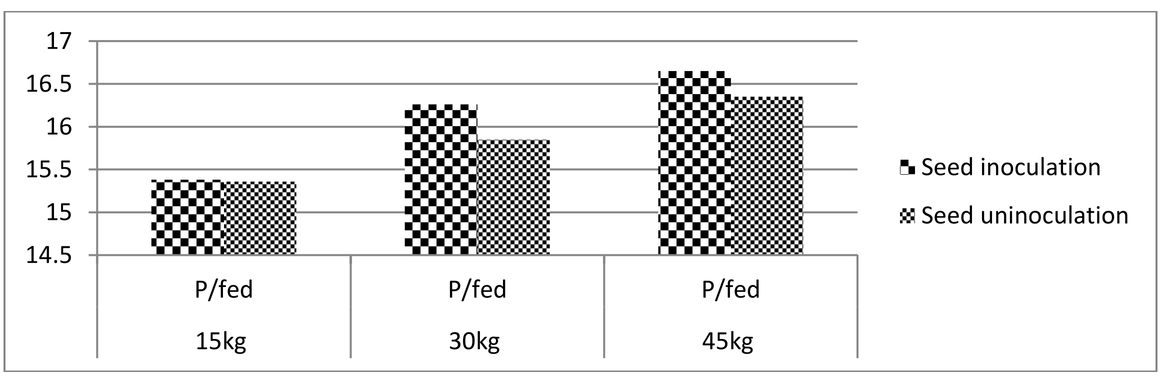

Figure 5. Means of velocity coefficient as a function of seed inoculation and phosphorus fertilization levels throughout the 2018 growing season.

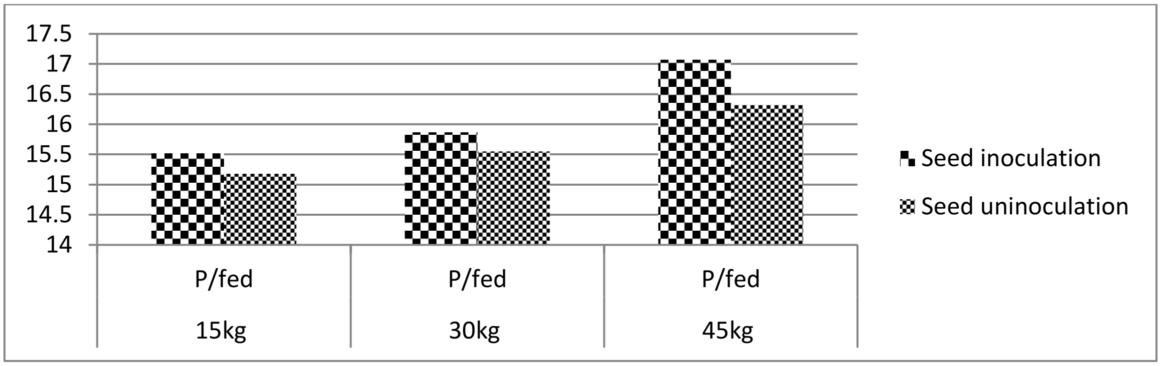

Figure 6. During the 2018 growing season, the interplay between seed inoculation and phosphorus fertilization levels altered the mean value of vigor.

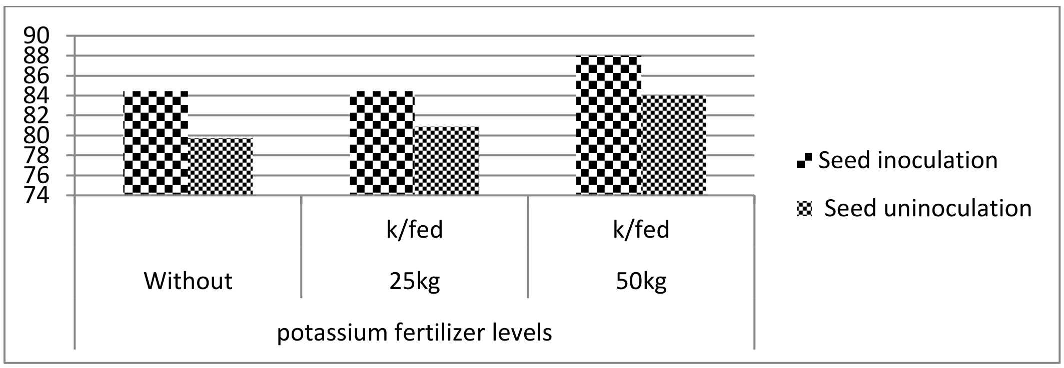

Figure 7. During the seasons of 2019 and 2020, the interplay between seed inoculation and potassium fertilization levels impacted the mean germination percentage.

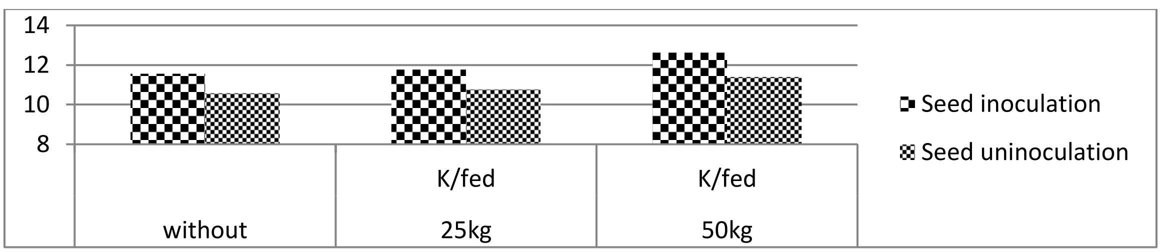

Figure 8. Means of germination index from seed inoculation and potassium fertilization levels throughout the 2019 growing season.

The seed inoculation genotype and addition of potassium fertilization at 50 kg k/fed recorded the highest values (12.62) of germination index in 2019. At the same time, the lowest values from the germination index in the 2019 season were recorded from the sown seed uninoculation Kawmy-1 genotype (10.58) without potassium fertilization in 2019. The influence of seed inoculation and potassium fertilization levels on mean germination time in the 2019 season is graphically represented in (Figs.9). The results clearly showed that seed uninoculation genotype and addition of potassium fertilization at 50 kg P/fed recorded the lowermost values (3.17) of mean germination time in 2019 season. The highest values from mean germination time in 2019 were recorded from sown seed inoculation Kawmy-1 genotype (3.71) when without the potassium fertilization in 2019. The influence of seed inoculation and potassium fertilization levels on vigor value in the 2018 season is graphically represented in (Figs.10). The results clearly showed that seed inoculation genotype and addition of potassium fertilization at 50 kg k/fed recorded the highest values (16.81) of the value of the vigor in 2018 season. At the same time, the lowest values from the value of the vigor in the 2018 season were recorded from the sown seed uninoculation Kawmy1 genotype (15.46) when without potassium fertilization 2018 season.

D3. Interaction between phosphorus fertilization levels and potassium fertilization levels effects: Interaction between phosphorus and potassium fertilization levels significantly affected germination percentage germination index in both seasons. Germination rate, mean germination time, velocity coefficient in the 2018 season and value. The vigor in both seasons is presented in (Tables 1 and 2). The effect of the interplay of phosphate and potassium fertilization levels on germination % in both seasons is graphically represented in (Figs. 11). The results clearly showed that the addition of phosphorus fertilization at 45 kg P/fed and the addition of potassium fertilization at 50 kg k/fed recorded the highest values of germination percentage (87.33, 88.00) in the first and second seasons, respectively. The lowermost values from germination percentage were recorded from the addition of phosphorus fertilization at 15 kg p/fed (80.00, 78.33) when fertilized without potassium fertilization in the first and second seasons, respectively. In the 2018 season, the interaction between phosphate and potassium fertilization levels on germination rate was graphically demonstrated in (Figs. 12). The results clearly showed that the addition of phosphorus fertilization at 45 kg P/fed and potassium fertilization at 50 kg k/fed recorded the highest values of germination rate (0.619) in 2018. The lowest values from the germination rate in the 2018 season were recorded from the addition of phosphorus fertilization at 15 kg P/fed (0.502) when fertilized without potassium fertilization in the 2018 season. The connection between phosphate and potassium fertilization amounts on germination index was graphically represented in (Figs.13). The results clearly showed that the addition of phosphorus fertilization at 45 kg p/fed and the addition of potassium fertilization at 50 kg k/fed recorded the highest values of germination index (14.77 and 12.63) in the first and second seasons, respectively. The lowermost values from the germination index were recorded from the addition of phosphorus fertilization at 15 kg P/fed (11.67, 10.77) when fertilized without potassium fertilization in the first and second seasons, respectively. (Figures 14 and 15) show the impact of the link between phosphorous and potassium fertilizer levels on mean germination time in the 2018 season. The results clearly showed that the addition of phosphorus fertilization at 45 kg P/fed and potassium fertilization at 50 kg K/fed recorded the lowermost values of mean germination time (2.19) in 2018. The highest values from mean germination time in the 2018 season were recorded from the addition of phosphorus fertilization at 15 kg P/fed (3.61) when fertilized without potassium fertilization in the 2018 season. The effect of the interaction between phosphate and potassium fertilization levels on the coefficient of velocity in the 2018 season is graphically represented in (Figs.15). The results clearly showed that the addition of phosphorus fertilization at 45 kg P/fed and addition of potassium fertilization at 50 kg k/fed recorded the highest values of coefficient of velocity (17.04) in 2018 season. The lowermost values from the coefficient of velocity in the 2018 season were recorded from the addition of phosphorus fertilization at 15 kg P/fed (15.47) when fertilized without potassium fertilization in the 2018 season. The results are graphically illustrated in (Figs. 16) the interaction's outcome effect between phosphorus fertilization levels and potassium fertilization levels on the value of the vigor. The results clearly showed that the addition of phosphorus fertilization at 45 kg P//fed and the addition of potassium fertilization at 50 kg K/fed recorded the highest values of the value of vigor (17.16, 16.45), respectively, in the first and second seasons. While the lowermost values from the value of the vigor were recorded from the addition of phosphorus fertilization at 15 kg P/fed (15.12, 13.62) when fertilized without potassium fertilization in the first and second seasons, respectively.

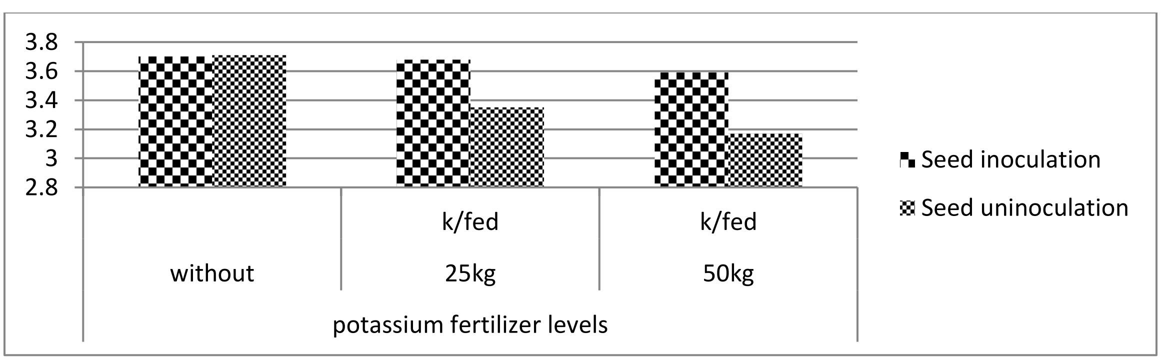

Figure 9. Means of germination time in seasons 2019 as influenced by the interplay between seed inoculation and potassium fertilization levels.

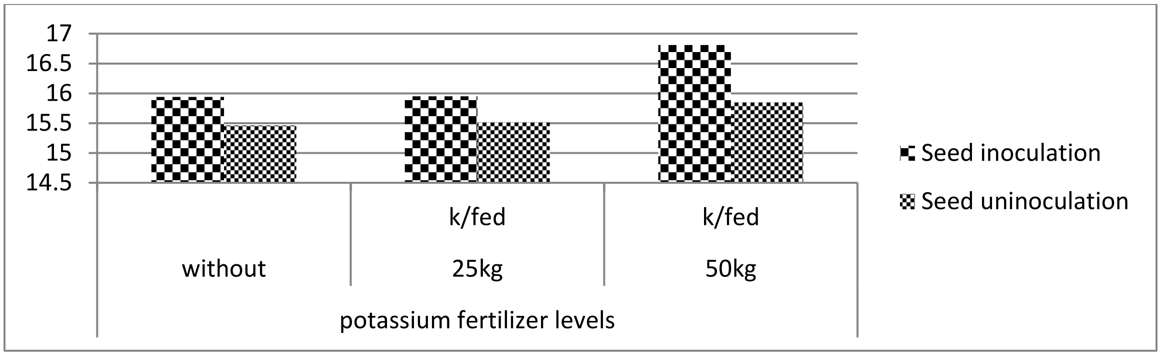

Figure 10. Means of vigor from seed inoculation and potassium fertilizer levels throughout the 2018 growing season.

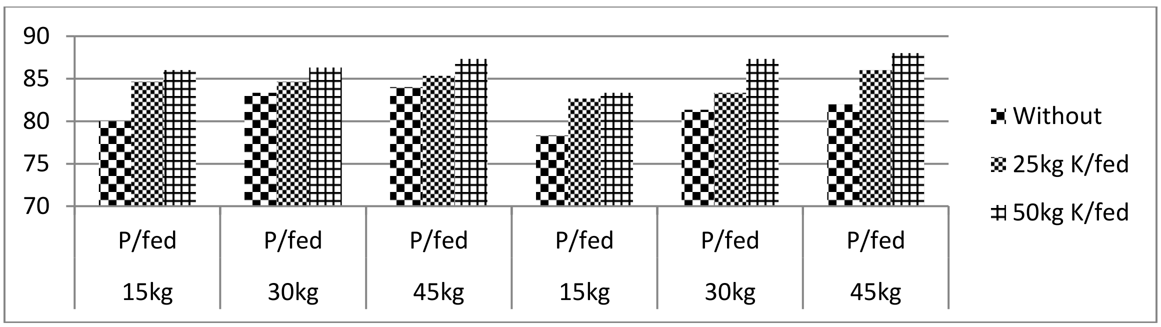

Figure 11. During the seasons of 2018 and 2019, the relationship between phosphorus and potassium fertilization levels altered the mean germination percentage.

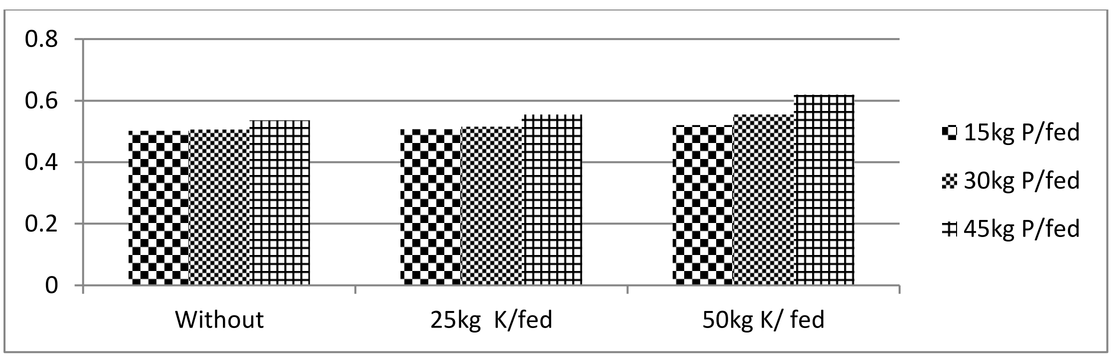

Figure 12. During the 2018 growing seasons, the interplay between phosphorus and potassium fertilization levels influenced the mean germination rate.

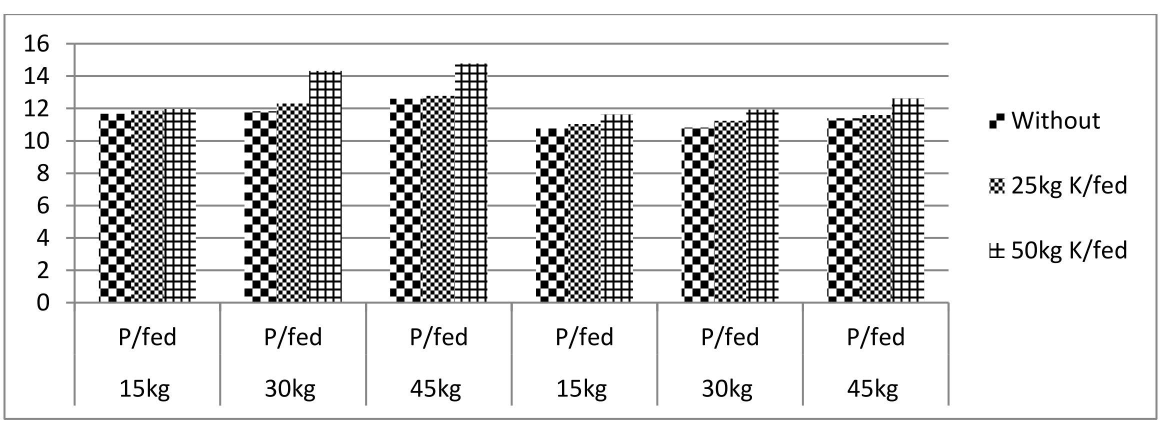

Figure 13. During the seasons of 2018 and 2019, the relationship between phosphorus and potassium fertilization levels altered the mean germination index.

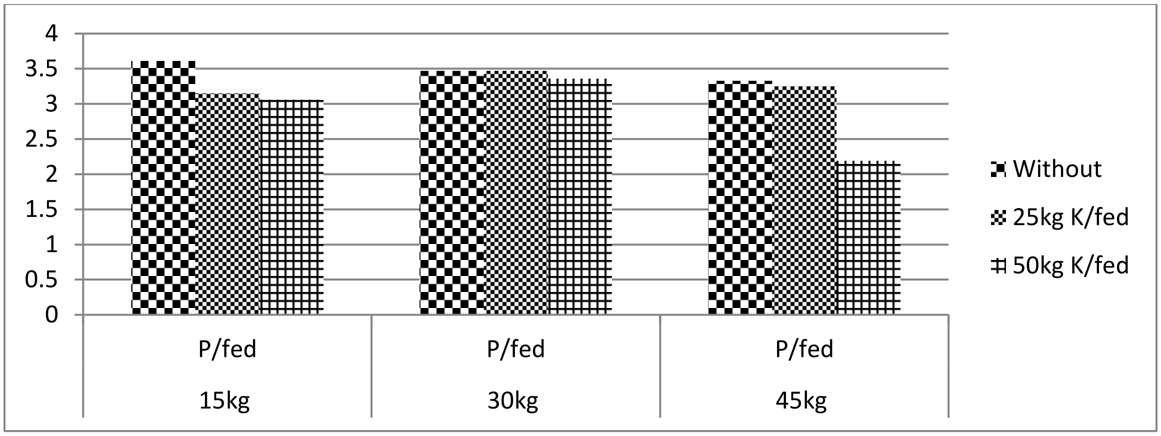

Figure 14. During the 2018 season, the interplay between phosphorus and potassium fertilization levels altered the average germination time.

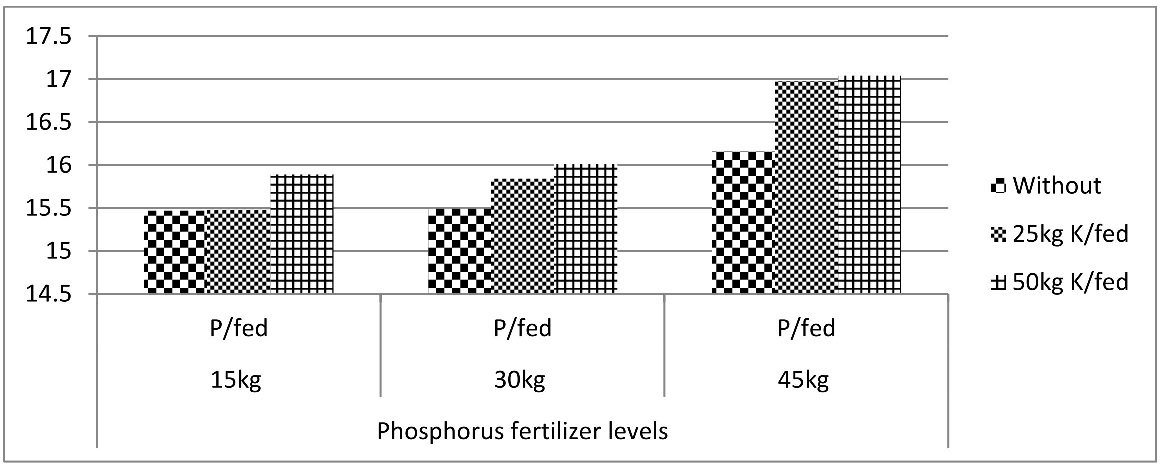

Figure 15. Means of velocity coefficient during seasons 2018 as influenced by the interplay between phosphorus and potassium fertilization levels.

D4. Interaction among seed inoculation, phosphorus fertilization levels and potassium fertilization levels effects: Seed inoculation, Phosphorus fertilization levels and potassium fertilization levels interaction significantly affected germination percentage in both seasons, germination index and value of the vigor in the 2019 season as presented in (Tables 1 and 2). The effect of seed inoculation, phosphorus and potassium fertilization levels on germination percentage was graphically illustrated in (Figs.17). The results clearly showed that seed inoculation, addition of phosphorus fertilization at 45 kg P/fed and addition of potassium fertilization at 50 kg k/fed, recorded the highest values of germination percentage (89.33 and 90.67) in the first and second seasons, respectively. The lowermost values from germination percentage were recorded from seed uninoculation addition of phosphorus fertilization at 15 kg P/fed (78.67 and 77.33) when fertilized without potassium fertilization in the first and second seasons, respectively. The outcomes are presented graphically in (Figs.18), which shows the effect of the interaction among seed inoculation, phosphorus fertilization levels, and potassium fertilization levels on the germination index in the 2019 season. The results clearly showed that seed inoculation, addition of phosphorus fertilization at 45 kg P/fed and addition of potassium fertilization at 50 kg K/fed recorded the highest values of germination index (12.20) in the 2019 season, the lowermost values from germination index were recorded from seed uninoculation, addition of phosphorus fertilization at 15 kg P/fed (9.73) when fertilized without potassium fertilization in 2019 season. The influence of seed inoculation, phosphorus and potassium fertilization levels on vigor value in the 2019 season is graphically represented in (Figs.19). The results clearly showed that seed inoculation, the addition of phosphorus fertilization at 45 kg p/fed, and the addition of potassium fertilization at 50 kg K/fed recorded the highest values of the value of the vigor (15.75) in 2019 season While the lowermost values from value of the vigor were recorded from Seed uninoculation, the addition of phosphorus fertilization at 15 kg P/fed (13.37) when fertilized without potassium fertilization in 2019.

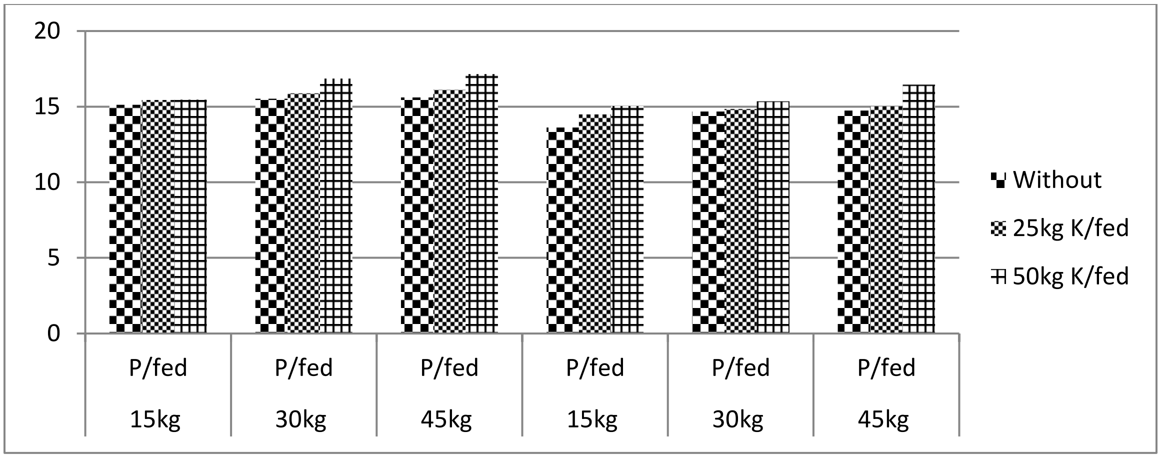

Figure 16. During the seasons of 2018 and 2019, the interplay between phosphorus and potassium fertilization levels altered the mean value of the vigor.

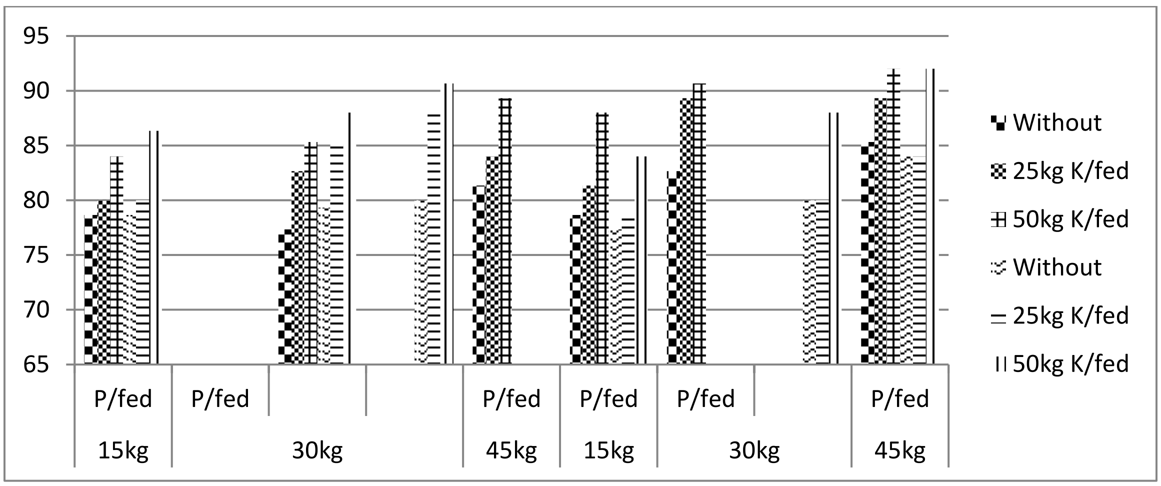

Figure 17. During the seasons of 2018 and 2019, the interplay between seed inoculation, phosphorus fertilization and potassium fertilization levels impacted the mean germination percentage.

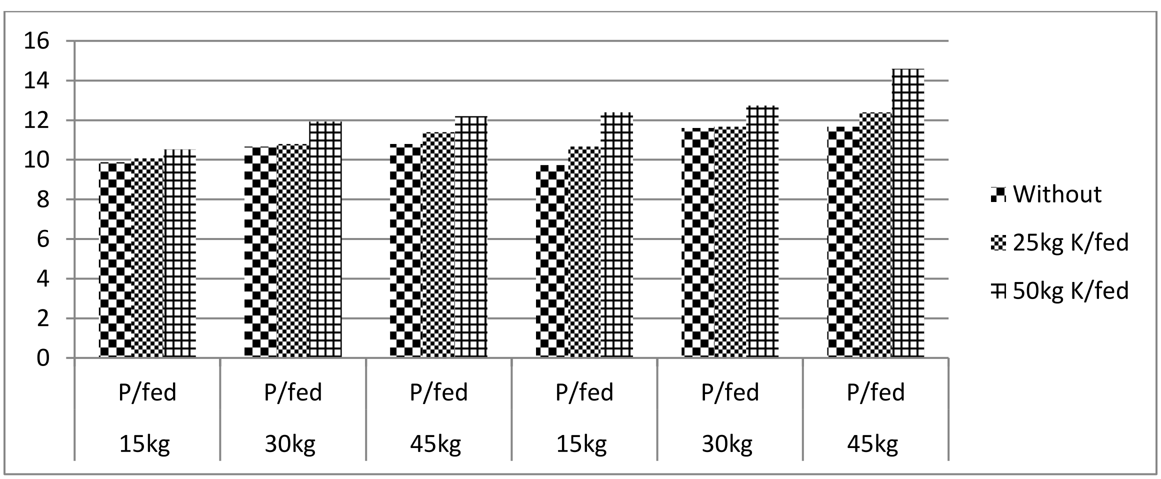

Figure 18. Means of germination index as a function of seed inoculation, phosphorus and potassium fertilization levels throughout the 2019 growing season.

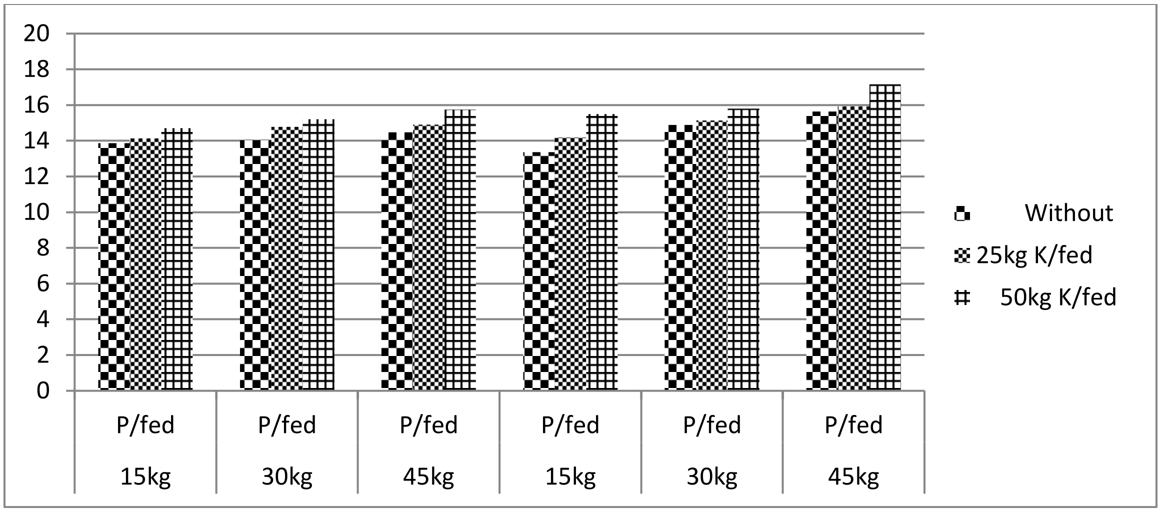

Figure 19. Means of vigor as a function of seed inoculation, phosphorus and potassium fertilization levels throughout the 2019 growing season.

Conclusion

According to the findings of this study, inoculating mung bean Kawmy 1 cultivar seeds with Rhizobium and fertilizing with 45 kg P2O5/fed and 50 kg K2O/provided improved seed germination and viability under the Giza Governorate's climatic conditions.

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Conflict of interest statement

The authors state no conflict of interest.

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