

Physiological Studies on Pea Nutrition And Production

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Two separate experiments on pea (*Pisum sativum* L.) cv. Master B were carried out at the farm of the production sector, Ministry of Agriculture, Egypt at Moshtohor, Kaliobia during the winter seasons of 2003/2004 & 2004/2005. Seeds were sown in the field of clay loam soil with pH 7.5 at 15th October of both seasons. Field experiments were carried out as follows :First Experiment : "Effect of P-fertilizer level and biofertilizer application on growth, chemical composition of plant foliage, green pod and dry seed yield of pea and its quality" This experiment included 28 treatments which were the combinations of 4 P-fertilizer levels; 0, 16, 32 and 48 kg P₂₀₅/fed. as calcium superphosphate (16% P₂₀₅) within 7 sources of seed inoculation with biofertilizers; control (without biofertilizer + 100% of the recommended N-dose), Phosphorin, control (without biofertilizer + 50% of the recommended N-dose), Microbien, Rhizobacterin, Rhizo. + Microbien and Rhizo. + Phosphorin). All biofertilizer treatments received 50% of the required N-dose except phosphorin and its control treatment supplied with 100% of the required N-dose. Treatments were arranged in split plot design with 4 replicates. P-fertilizer levels served as main plots and biofertilizer sources served as sub-plots. All treatments received 48 kg K₂₀/fed. as potassium sulphate (48% K₂₀) and nitrogen was added at 50 or 100% of the recommended N-dose, i.e. 20 or 40 kg N/fed. as ammonium sulphate (20.5% N) as previously mentioned. Other agricultural practices were done as commonly followed in the district. Obtained results revealed at the following :

1- Vegetative growth characteristics : a-Increasing level of P-application from 0, 16 up to 32 kg P₂₀₅/fed. significantly and gradually encouraged pea vegetative growth expressed as plant height, number of leaves, fresh and dry weight/plant in both seasons. whereas, number of branches/plant was significantly increased only in the second season. Heavy application at 48 kg P₂₀₅/fed. significantly decreased number of leaves, fresh and dry weight/plant of pea as compared with that of plants supplied with 32 kg P₂₀₅/fed., as a general trend in both seasons. b-Results showed that all used biofertilizers significantly improved plant growth than the control. Moreover, inoculating pea seeds with a mixed of two biofertilizers; Rhizobacterin + Phosphorin or Rhizobacterin + Microbien encouraged plant growth than inoculating with only one biofertilizer (phosphorin, Microbien or Rhizobacterin). Results also showed that inoculating seeds with a mixed biofertilizer contained Rhizobacterin + Phosphorin gave the highest vegetative growth expressed as plant height, number of leaves, fresh and dry weight/plant as compared with the control (without biofertilizer) or when biofertilizer was added in a single form, in both seasons. Meanwhile, number of branches/plant was markedly increased by using biofertilizer only in the second season. c-Concerning with the interaction effect between P-fertilizer level and biofertilizer application on vegetative growth, results revealed that plants received phosphorus fertilizer level at 32 kg P₂₀₅/fed. and pea seeds inoculated with Rhizobacterin + Phosphorin significantly increased plant height, number of leaves and dry weight/plant as compared with all other treatments, in both seasons. While, fresh weight/plant was considerably increased only in the first season. But, number of branches per plant did not show any significant differences in both seasons.

2- Chemical composition of plant foliage : 2.1. Photosynthetic pigments content of leaves : a-Increasing level of P-fertilizer from 0, 16 up to 32 kg P₂₀₅/fed. gradually and significantly increased chlorophyll a, b and total chlorophyll as well as carotenoids content of pea leaves. This trend was true in both seasons. However, P-application at

48 kg P205/fed. did not significantly increase photosynthetic pigments content of leaves as compared with that of plants supplied with 32 kg P205/fed.

b-Inoculating pea seeds with a mixture of two biofertilizers; Rhizobacterin + Phosphorin was the best treatment resulted the highest chlorophyll a, b, total chlorophyll and carotenoids content of leaves as compared to other biofertilization treatments or the control (without biofertilizer).

Summary and Conclusion -155-

c-Regarding with the interaction effect between P-fertilizer level and biofertilizer source on photosynthetic pigments, the inoculation of pea seeds with Rhizobacterin + Phosphorin + 50% of the recommended N dose + 32 kg P,05/fed. led to a significant increment in chlorophyll a, b and total chlorophyll in both seasons. While, total carotenoids was significantly increased only in the first season.

2.2. N,P and K content of plant foliage :

a- Increasing P-fertilizer level from 0,16 up to 32 kg P205/fed. gradually and significantly increased N,P and K% of plant foliage, as shown in both seasons. whereas, the high level of P-application at 48 kg P205/fed. significantly decreased minerals content; NPK of plant foliage than those of plants received 32 kg P205/fed. This trend was true in both seasons.

b-Results showed that using a mixture of biofertilizer (Rhizobacterin + Phosphorin) to inoculate pea seeds gave the highest N,P and K content of plant foliage compared with using single biofertilizer i.e. Phosphorin, Rhizobacterin or Microbien or control when no biofertilizer was added, as a general trend in both seasons.

c-Concerning with the interaction effect between P-fertilizer level and biofertilizer source on N,P and K content of plant foliage, results indicated that fertilizing pea plants with 32 kg P205/fed. and inoculating seeds with Rhizobacterin + Phosphorin produced the highest NPK content of plant

Summary and Conclusion -156-

foliage as compared with the other tested treatments, as shown in both seasons.

3- Green pod yield and its components :

a-Increasing level of phosphorus fertilizer from 0,16 up to 32 kg P205/fed. gradually and significantly increased green pod yield and its components expressed as, number of pods/plant, average pod weight, seed index, netting%, green pod yield/plant and per fed. in both seasons. However, plants supplied with the high level of phosphorus fertilizer; 48 kg P205/fed. significantly decreased green pod yield/plant and per fed. and its components compared with the optimum level; 32 kg P205/fed.

b-The highest values of green pod yield and its components, i.e. number of pods/plant, average pod weight, pod length, number of seeds/ pod, netting%, seed index, green pod yield/plant and per fed. were obtained by inoculating pea seeds with Rhizobacterin + Phosphorin as compared with using biofertilizer in a single form (Phosphorin, Microbin or Rhizobacterin) or the control treatment (without biofertilizer). This best treatment increased green pod yield with 2.75 and 2.55 ton/fed. consisted 105.07% over than the control.

c-According to the interaction effect between P-fertilization level and biofertilizer applications on green pod yield and its components, results showed that adding 32 kg P205/fed. and inoculating pea seeds with a mixed biofertilizers; Rhizobacterin (containing N-fixing bacteria) + Phosphorin (containing PDB) gave the highest green pod yield/plant

Summary and Conclusion -157-

and per fed. as compared with the other tested treatments. This increment in green pod yield was 4.779 and 4.01 tons/fed. over than the control in the first and second season, respectively consisted 99.20% as an average of both seasons.

4- Dry seed yield and its components :

a-Increasing P-fertilizer level from 0,16 up to 32 kg P205/fed. gradually and significantly increased number of pods/plant, dry seed yield/plant and per fed., as a general trend in both seasons. whereas, number of seeds per pod, dry seed weight/pod and seed index were significantly increased by increasing level of P-application only in the first season. However, increasing P-fertilizer level from 0,16,32 up to 48 kg P205/fed. did not affect each of average pod weight and netting percentage in both seasons. In addition, adding increasing level of P-application up to 48 kg P205/fed. decreased all studied parameters of dry seed yield as compared with that of plants received 32 kg P205/fed. as shown in both experimental seasons.

b-According to the effect of biofertilizer application on dry seed yield and its components, results showed that the inoculation of pea seeds with a mixed biofertilizers; Rhizobacterin + Phosphorin produced higher dry seed yield and improved its components than that of plants treated with a single biofertilizer or the control, as a general trend in both seasons. This increment in dry seed yield was 1.197, 1.193 tons/fed. for the first and second season,

Summary and Conclusion -158-

respectively consisted 171.89% over than the control as an average of both seasons.

c-Regarding with the interaction effect between P-fertilizer level and biofertilizer application, results revealed that the highest dry seed

yield/plant and per fed. with the best components was obtained when plants fertilized with 32 kg P₂O₅/fed. and inoculating seeds with Rhizobacterin + Phosphorin plus supplied with 50% of the required N-dose, as a general trend in both seasons. However, number of seeds/pod, average pod weight, dry seed weight/pod and netting% as well as seed index did not significantly increase by all treatments in both seasons. This super treatment increased dry seed yield over than the control 1.631 and 1.763 tons/fed. in the first and second seasons, respectively. This increment consisted 201.05% over the control as an average in both seasons.

5- Chemical composition of green and dry seeds :

5.1. Chemical composition of green seeds :

a-Results showed that increasing P-fertilizer level from 0,16 up to 32 kg P₂O₅/fed. gradually and significantly increased N,P, K reducing and/or non reducing sugars content of green seeds. However, heavy P-fertilization; 48 kg P₂O₅/fed. led to decrease NPK content of green seeds as compared with that of plants supplied with the optimum P-fertilizer level; 32 kg P₂O₅/fed. this trend was true during both seasons.

b-Inoculating pea seeds with a single or mixed biofertilizer increased N,P,K, reducing, non-reducing and total sugars.

Summary and Conclusion -159- content of green seeds as compared with the control treatment (without biofertilizer). Moreover, using mixed biofertilizers i.e. Rhizobacterin + Phosphorin gave the highest NPK content of green seeds as compared with using biofertilizer in a single form, as a general trend in both seasons.

c-As for the interaction effect between P-fertilizer level and biofertilizer source on minerals content of green seeds, results showed that plants supplied with 32 kg P₂O₅/fed. and seed inoculated with Rhizobacterin + Phosphorin with 50% of the recommended N-dose significantly increased P content of green seeds in both seasons. However, N,K, reducing and/or non-reducing sugars content did not show any significant differences between the interaction treatments in both seasons.

5.2. Chemical composition of dry seeds :

a-Results showed that increasing P-fertilizer level from 0,16 up to 32 kg P₂O₅/fed. resulted a significant increase in N,P,K and crude protein content of dry seeds, as a general trend. whereas, increasing P-application up to 48 kg 13,05/fed, significantly decreased N,P,K and protein content of dry seeds as compared with that of plants received 32 kg 13,05/fed., as shown in both seasons.

b-According to the effect of biofertilizer source on chemical composition of dry seeds, results showed that inoculating pea seeds with single or mixed biofertilizer improved N,P,K and crude protein content of dry seeds than the control with no biofertilizer. Moreover, the inoculation with

Summary and Conclusion -160- Rhizobacterin + Phosphorin gave the highest values of N,P and K as well as crude protein content of dry seeds as compared with the inoculation with a single biofertilizer or the control, as shown in both seasons.

c- Regarding with the interaction effect of P-fertilizer level within biofertilizer source on chemical composition of dry seeds, results indicated that supplying plants with 32 kg P₂O₅/fed. associated with Rhizobacterin + Phosphorin and fertilized with 50% of the required N-dose led to a significant increase in P and K content of dry seeds in both seasons. However, N and crude protein content were significantly increased only in the first season as compared with the other tested treatments.

Conclusion : As for fertilizing pea plants cv. Master B grown for green pod and dry seed yield, it could be recommended that adding calcium superphosphate at 32 kg P₂O₅/fed. and inoculated pea seeds with Rhizobacterin + Phosphorin plus using ammonium sulphate at 20 kg N/fed (equal to 50% of the recommended N-dose) in order to increase plant growth, green pod and dry seed yield/fed and improve yield components. This treatment led to an increment in green pod yield/fed reached 3.90 and 3.10 tons/fed and the increment in dry seed yield/fed. reached 1.40 and 1.66 tons/fed. as compared with the control when no biofertilizer was used in the first and second season, respectively and saved 50% of the recommended N-dose. The average relative increase over the control reached 80.79% and 151.57% in green pod and dry seed yield, respectively.

Summary and Conclusion -161- **Second Experiment :** "Effect of P-fertilizer source and biofertilizer application on vegetative growth, green pod yield, dry seed yield and its components as well as chemical composition of plant foliage and seeds" This experiment included 8 treatment which were the combinations of two sources of phosphorus fertilizer; (superphosphate 16% P₂O₅ and rock phosphate 30% P₂O₅) within 4-biofertilizer applications (control without biofertilizer, Rhizobacterin, Mycorrhiza and Rhizobacterin + Mycorrhiza). Treatments were arranged in split plot design with 4-replicates. whereas, P-fertilizer source served as main plots and biofertilizer applications served in sub-plots. All treatments received 32 kg P₂O₅/fed. + 20 or 40 kg N as ammonium sulphate (20.5% N)

except treatments inoculated with Rhizobacterin received only 20 kg N/fed. consist 50% of the recommended N-dise.+ 48 kg K₂O as potassium sulphate (48% K₂O). Other agricultural practices were done as commonly followed in the district. Obtained results revealed the following :

1- Vegetative growth characteristics :a- Using rock phosphate as a P-fertilizer source significantly increased plant height, fresh and dry weight/plant in both seasons as compared with that of plants supplied with superphosphate. While, number of leaves/plant was significantly increased by rock phosphate only in the first season. However, number of branches/plant did not differ by using either superphosphate or rock phosphate, in both seasons.

4Summary and Conclusion-162-b-Results showed that inoculating pea seeds with Rhizobacterin and inoculating soil with Mycorrhiza significantly increased plant vegetative growth expressed as plant height, number of leaves, fresh and dry weight/plant as compared with using a single biofertilizer; Rhizobacterin or Mycorrhiza or the control treatment. Obtained results were true during both seasons of this study. However, number of branches/plant did not show any significant increase in both seasons with all studied treatments.

c-According to the interaction effect between P-fertilizer source and biofertilizer application on vegetative growth, results showed that fertilizing pea plants with rock phosphate and inoculating seeds with Rhizobacterin + inoculating soil with Mycorrhiza significantly increased number of leaves/plant, fresh and dry weight/plant as a general trend in both seasons as compared with the other treatments, while, plant height was significantly increased only in the second season. But, number of branches/plant was not significantly affect by any treatments in both seasons.

2-Chemical composition of plant foliage :2.1. Photosynthetic pigments content of leaves :a-Results indicated that fertilizing pea plants with rock phosphate greatly increased chlorophyll a,b and total chlorophyll as well as carotenoids content of leaves as compared with that of plants fertilized with superphosphate,as shown in both seasons.

b-Adding two biofertilizers; Rhizobacterin + Mycorrhiza markedly increased photosynthetic pigments content of peaSummary and Conclusion -163-leaves as compared with adding a single biofertilizer or thecontrol (without biofertilizer). This trend was true in both seasons.

c- Concerning with the interaction effect of P-fertilizer source and biofertilizer treatments on chlorophyll and carotenoids content of leaves, results revealed that chlorophyll a and/or b and carotenoids content of leaves seemed to increase in plants supplied with rock phosphate and received double biofertilizer of Rhizobacterin + Mycorrhiza, but, this increment failed to reach the level of significance, in bothseasons except for chlorophyll a it was significantly increased only in the second season.

2.2. N,P and K content of plant foliage :a-Results showed that using rock phosphate as a source of P-fertilization significantly increased NPK content of plantfoliage as compared with using calcium superphosphate, as shown in both seasons.

b-Treating pea seeds with Rhizobacterin and inoculating soil with Mycorrhiza led to a significant increase in N,P and K content of plant foliage comared with using biofertilizer in a single form i.e. Rhizobacterin or Mycorrhiza or thecontrol treatment (when no biofertilizer was added). This results are true during both seasons.

c-As for the interaction effect between P-fertilizer source and biofertilizer application on NPK content of plant foliage, results showed that there were no considerable effect onNPK content of plant foliage due to the interaction treatments in both seasons.

Summary and Conclusion -164-3- Green pod yield and its components :a-Results reported that green pod yield/plant and per fed. were increased by supplying plants with rock phosphate compared with superphosphate, as shown in both seasons. However, average pod weight, pod length and number of seeds/pod were not significantly affect by source of P-fertilization, especially in the first season. This increment in green pod yield by using rock phosphate could be explained by the improvement in number of pods per plant, netting percentage and weight of 100 seeds (seed index), as shown in both seasons. Green pod yield increment reached 31.06 and 41.63% by using rock phosphate compared with superphosphate in the first and second season, respectively.

b-According to the effect of biofertilizer application on green pod yield and its components, results showed that using biofertilizer; Rhizobacterin and/or Mycorrhiza markedly increased green pod yield and its components as compared with the control i.e. when no biofertilizer was added. In this respect, the best treatment gave the highest fresh pod yield with the best components was obtained by adding two types of biofertilizers; Rhizobacterin + Mycorrhizawhich produced the highest green pod yield per fed. (6.7 tons/fed.) compared with the control (2.34 tons/fed.) as an average of both seasons. Yield increment

reached 2.13 and 1.63 times than the control in the first and second seasons, respectively.

c- Concerning with the interaction effect between P-fertilizer source and biofertilizer application, results indicated that

Summary and Conclusion -165-

fertilizing pea plants with rock phosphate and treating seeds with Rhizobacterin as well as inoculating soil with Mycorrhiza led to a significant increase in green pod yield/plant and per fed. as compared with the other treatments. This trend was true during both seasons. This increment may be attributed to the increment in number of green pods/plant and netting% in both seasons. whereas, seed index was significantly increased only in the first season. However, average pod weight, pod length and number of seeds/pod did not show any significant increase by any treatment in both seasons. The increment in green pod yield/fed. by using this superior treatment reached 4.855 and 4.651 tons/fed in the first and second season, compared with the control respectively.

4- Dry seed yield and its components

a- Results showed clearly that fertilizing pea plants with rock phosphate enhanced most studied parameters of dry seed yield i.e. dry seed weight per pod, dry seed yield/plant and per fed. as compared with that of superphosphate, as a general trend in both seasons. However, number of pods/plant, average pod weight, number of seeds/pod, netting% and seed index were significantly increased only in one season. The increment in dry seed yield/fed reached 224, 268 kg/fed. consisted 20.76, 24.75% by using rock phosphate compared with that of superphosphate in both seasons of this experiment.

b- Results also showed that inoculating seeds with Rhizobacterin associated with inoculating soil with

Summary and Conclusion -166-

Mycorrhiza significantly and markedly increased dry seed yield/plant and per fed. and improved its components as compared with the single biofertilizer; Rhizobacterin or Mycorrhiza or the control in both seasons. While, seed index was increased only in the first season. However, netting% did not show any significant increase in both seasons. This increment in dry seed yield/fed. reached 21.83, 63.03 and 124.04% with Rhizobacterin, Mycorrhiza and Rhizobacterin + Mycorrhiza, respectively over than the control as an average for both seasons. It was clear that the highest dry seed yield was obtained by the superior treatment; Rhizobacterin + Mycorrhiza which increased dry seed yield/fed. 1.24 times than the control and saved 50% of recommended dose of N-fertilizer.

c- According to the interaction effect between P-fertilizer source and biofertilizer treatments on dry seed yield and its components, results cleared that fertilizing pea plants with rock phosphate plus inoculation with Rhizobacterin + VAM significantly increased dry seed yield/plant and per fed. as shown in both seasons compared with the other treatments. This increment may be due to the increment in number of pods/plant. Applying the superior treatment i.e. rock phosphate plus Rhizobacterin + Mycorrhiza produced the highest dry seed yield reached 1.12 and 1.16 tons/fed. as compared with the control treatment (without biofertilizer) in the first and second season, respectively.

Summary and Conclusion -167-

5- Chemical composition of green and dry seeds : 5.1. Chemical composition of green seeds

a- Fertilizing pea plants with rock phosphate markedly increased NPK, reducing, non-reducing and total sugars content of green seeds compared with that of plants fertilized with superphosphate as shown in both experimental seasons.

b- As for the effect of biofertilizer treatments on N,P and K content of green seeds, results indicated that Rhizobacterin and/or Mycorrhiza increased NPK and reducing and/or non reducing sugars content of green seeds than that of control treatments; when no biofertilizer was added. In this concern, treating pea with Rhizo. + Mycorrhiza gave the highest N,P and K content of green seeds as compared with adding biofertilizer in a single form i.e. Rhizobacterin or VAM or the control.

c- Regarding with the interaction effect between P-fertilizer source and biofertilizer treatments on NPK content of green seeds, results did not show any significant affect on N,P, K and reducing and/or non-reducing sugars content of green seeds in both seasons. It means that there were no considerable interaction effect between treatments of P-fertilizer source within biofertilizer application on NPK content of green seeds.

5.2. Chemical composition of dry seeds

a- Results showed that N,P,K and crude protein content of dry seeds were increased significantly by supplying pea plants

Summary and conclusion -168-

with rock phosphate as compared with plants received superphosphate. These results were true in both seasons.

b- With regard to the effect of biofertilizer application on NPK and crude protein content of dry seeds, results revealed that using biofertilizer as Rhizobacterin + Mycorrhiza markedly increased minerals content; N,P and K as well as protein content of dry seeds compared with using a single biofertilizer i.e. Rhizobacterin or

Mycorrhiza or the control treatment (without biofertilizer), as a general trend in both seasons. c- Concerning with the interaction effect between P-fertilizer and biofertilizer treatments on NPK and crude protein content of dry seeds, results showed that fertilizing pea plants with rock phosphate and inoculating seeds with Rhizobacterin associated with treating soil with Mycorrhiza led to an increase in N, K and protein content of dry seeds, especially in the first season, as compared with the other tested treatments. whereas, P-content of dry seeds failed to reach the level of significance during both seasons. Conclusion : As for fertilizing pea plants cv. Master B grown for green and dry seed yield, it could be recommended that adding rock phosphate as a source of P-fertilization and inoculating seeds with Rhizobacterin associated with inoculating soil with Mycorrhiza in order to increase plant growth, green pod and dry seed yield/fed and to improve yield components. The increment in green pod yield/fed. reached 4.855 and 4.651 ton/fed. and the increment of dry seed yield/fed. reached 1.12 and 1.16 tons/fed. Summary and Conclusion -169- compared with the control in the first and second season, respectively and saved 50% of the recommended N-dose. The relative increase reached 175.31 and 128.37% over the control for fresh pod and dry seed yield, respectively.