Indian J. Plant Physiol., Vol. 14, No. 3, (N.S.) pp. 278-282 (July-Sept., 2009)

AUGMENTING PHOTOSYNTHESIS, ENZYME ACTIVITIES, NUTRIENT CONTENT, YIELD AND QUALITY OF SENNA SOPHERA (*CASSIA SOPHERA* L.) BY P FERTILIZATION

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Received on 5 Jan., 2009, Revised on 11 Sept., 2009

SUMMARY

In a pot experiment, the performance of senna sophera (a medicinal herb) was studied under five basal levels of phosphorus (0, 25, 50, 75 and 100 mg P kg^{-1} soil). Physiological parameters were studied at 120, 150, 180 and 210 days after sowing (DAS). Application of 75 mg P kg^{-1} soil treatment was the most beneficial and gave 20.4% higher photosynthetic rate at 150 DAS, 16.7% higher carbonic anhydrase activity and 15.6% higher nitrate reductase activity at 120 DAS, and 24.5% higher seed yield and 13.6 % higher seed protein content at 210 DAS than the control (no phosphorus).

Key words: **Anthraquinone, carbonic anhydrase activity, *Cassia sophera* L., nitrate reductase activity, photosynthesis**

INTRODUCTION

Senna sophera (*Cassia sophera* L. family Fabaceae) commonly known as 'Kasunda' or 'Banar', is a potent medicinal herb. Its leaves possess purgative properties. A paste of leaves and root bark is a useful application in skin diseases like ringworm and ulcers and roots are considered diuretic (Anonymous 1992). The seeds are cathartic and are used as a febrifuge and administered in diabetes and in acute bronchitis (Dastur 1977, Kirtikar and Basu 1987). Plant parts contain glycosides of anthraquinones, chrysophenol, physcion and emodin used for various ailments like anxiety, constipation, diarrhoea and stress.

Most of the agricultural soils in India, including soils of western Uttar Pradesh, are phosphorus (P) deficient (Ghosh and Hassan 1977, Naeem and Khan 2009). Also, very little work has been done on the optimal fertilizer levels related to the yield and quality of senna. Therefore, an experiment was conducted to study the effect of different P levels on physiological aspects, yield and quality.

MATERIALS AND METHODS

Experiment was conducted in a net house at the Department of Botany, Aligarh Muslim University, Aligarh. Each pot was filled with 5.0 kg homogenous mixture of soil and farmyard manure (4:1). The soil mixture was sandy loam with pH (1:2) 7.3, E.C. (1:2) 0.50 dS m^{-1}, available nitrogen (N), P and potassium (K) 93.40, 7.28 and 142.2 mg kg^{-1} soil, respectively.

The seeds of senna sophera were obtained from the Regional Research Institute of Unani Medicine, Aligarh, India. Healthy seeds of uniform size were selected and their viability was tested using 1% tetrazolium salt. The seeds were surface sterilized with 95% ethyl alcohol for five minutes and then washed thoroughly with distilled water before sowing in pots (25 cm x 25 cm). One plant was maintained in each pot. Five basal levels of P, viz.

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0, 25, 50, 75 and 100 mg P kg^{-1} soil as potassium dihydrogen orthophosphate were applied just after sowing. Each treatment was replicated four times in a complete randomized design. The growth and biochemical attributes were determined at vegetative stage (120 DAS), flowering stage (150 DAS) and pod-filling stage (180 DAS). Yield and quality parameters were studied at harvest (210 DAS). The growth performance of the plants was studied in terms of fresh and dry weights. The biochemical parameters comprised net photosynthetic rate (P_N), stomatal conductance (gs), transpiration rate, total chlorophyll and carotenoid contents, nitrate reductase (NR) and carbonic anhydrase (CA) activities and leaf N, P, K and calcium (Ca) contents. Yield attributes included pods $plant^{-1}$, seeds pod^{-1}, 100-seed weight and seed-yield $plant^{-1}$. Quality characters included seed-protein content and total anthraquinone glycosides content.

P_N, gs and transpiration rate were measured using Li-Cor 6200 Portable Photosynthesis System (Lincoln, Nebraska, USA) on sunny days at 11.00 hour on fully expanded leaves only at 150 DAS. Total chlorophyll and carotenoid contents were estimated according to the method of Mac Kinney (1941) and MacLachlan and Zalik (1963) respectively using a spectrophotometer (Spectronic 20D, Milton Roy, USA). NR and CA activities were estimated by the method of Jaworski (1971) and Dwivedi and Randhawa (1974), respectively. Leaf N content was estimated by the method of Lindner (1944). The method of Fiske and Subba Row (1925) was used to estimate the leaf P content. Both leaf K and Ca contents were estimated with the help of emission spectra using specific filters in a flame-photometer (C150, AIMIL, India). The protein content of seeds was estimated by the method of Lowry *et al.* (1951). The total anthraquinone glycosides content of seeds was estimated by the spectrophotometric method (ASEAN Countries 1992). The data were analyzed statistically by adopting Gomez and Gomez (1984) and LSD was calculated at 5% level of probability.

RESULTS AND DISCUSSION

The effect of P application was found to be significant on physiological and biochemical attributes and growth characters studied at 120, 150 and 180 DAS, and yield and quality characteristics at 210 DAS. No significant improvement was observed in Ca content at 180 DAS and seeds pod^{-1}, 100-seed weight and total seed anthraquinone glycosides content at 210 DAS (Figs. 1-3, Table 1). Increasing levels of P up to 75 mg P kg^{-1} soil enhanced P_N, gs and transpiration rate at 150 DAS and chlorophyll and carotenoid contents, leaf NR

Table 1. Effect of phosphorus on growth characters and yield and quality attributes of senna sophera

Attributes	Phosphorus concentrations (mg P kg^{-1} soil)						
	DAS	0	25	50	75	100	LSD at 5 %
Fresh weight $plant^{-1}$ (g)	120	13.65	14.30	15.41	18.03	18.15	1.68
	150	67.32	70.48	73.20	93.27	93.59	3.12
	180	130.74	139.70	149.41	170.23	170.38	5.61
Dry weight $plant^{-1}$ (g)	120	2.70	3.35	3.40	3.75	3.80	0.366
	150	12.87	14.88	16.92	19.20	19.24	1.83
	180	23.72	28.80	31.35	34.70	34.75	2.51
Number of pods $plant^{-1}$		56.2	62.2	66.3	73.6	74.0	4.04
Number of seeds pod^{-1}		33.4	33.2	33.5	33.7	33.4	NS
100-seed weight (g)		1.86	1.85	1.87	1.90	1.86	NS
Seed-yield $plant^{-1}$ (g)		31.76	33.94	36.62	41.31	41.56	1.58
Seed-protein content (%)		15.64	16.33	16.78	17.76	17.85	0.546
Total anthraquinone glycosides content (%)		0.015	0.015	0.016	0.018	0.018	NS

N.S.= Non-significant

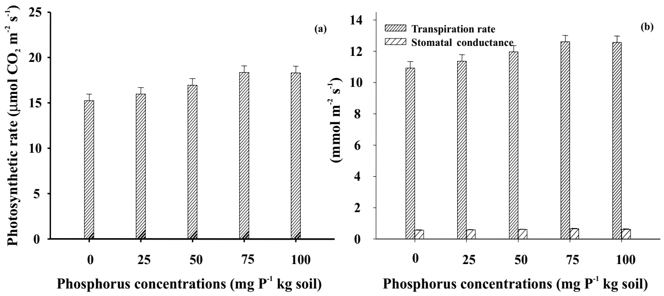

Fig. 1. Effect of five levels of phosphorus, viz. 0, 25, 50, 75 and 100 mg P kg^{-1} soil on net photosynthetic rate, transpiration rate and stomatal conductance of senna sophera studied at 150 DAS. LSD ($p \leq 0.05$) was employed to separate the means at the top of the bars

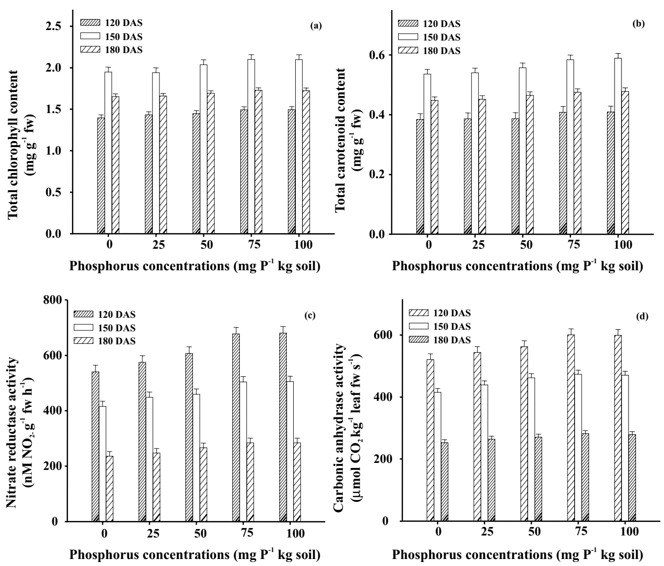

Fig. 2. Effect of five levels of phosphorus, viz. 0, 25, 50, 75 and 100 mg P kg^{-1} soil on total chlorophyll and carotenoid content and nitrate reductase and carbonic anhydrase activities of senna sophera studied at 120, 150 and 180 DAS.

and CA activities and leaf N, P, K and Ca content at 150 DAS (Figs 1-3). The beneficial effect of P may be due to promotion of synthesis of ribulose-1,5-bisphosphate (Rao and Terry 1989, Fredeen *et al*. 1990), ribulose-1,5-bisphosphate carboxylase and adenosine triphosphate (Dietz and Foyer 1986) and assimilation of carbon dioxide (Longstreth and Noble 1980). P being constituent of a number of metabolites could also be helpful in the synthesis of pigments and hence higher values for chlorophyll and carotenoid pigments were observed in treated plants (Fig. 2). The higher value for

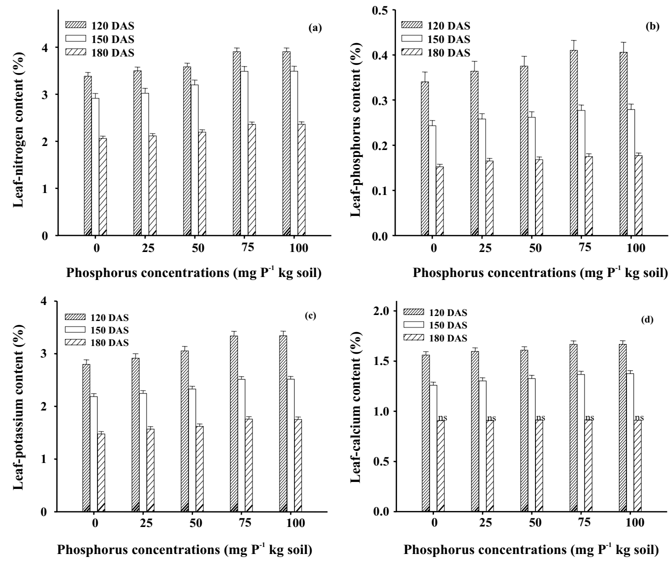

Fig. 3. Effect of five levels of phosphorus, viz. 0, 25, 50, 75 and 100 mg P kg^{-1} soil on leaf N, P, K and Ca contents of senna sophera studied at 120, 150 and 180 DAS.

NR activity due to P application was expected as application of fertilizers, particularly P was found to be effective for the enzyme activity (Oaks 1985). This finding corroborates with those of Naeem and Khan (2005) and Naeem *et al*. (2009) on other medicinal plants. A probable cause for the enhancement of CA activity due to P supply (Fig. 2) might be due to the positive influence of P on the *de novo* synthesis of CA, which involves translation/transcription (Okabe *et al*. 1980). The improvement in leaf N, P, K and Ca content due to P application could be explained on the basis of interaction effect. Thus, P encouraged the absorption of other nutrients hence higher values for nutrients in P treated plants (Fig. 3). Khan *et al*. (2000), Naeem and Khan (2005, 2009) and Naeem *et al*. (2009) also observed similar effect on other medicinal plants.

Fresh and dry weight plant^{-1} increased with increasing levels of P up to 75 mg kg^{-1} soil at the three growth stages (Table 1). This increase could be ascribed to the roles of P in metabolism and as a constituent of a number of metabolites including adenosine triphosphate, nicotinamide adenine dinucleotide phosphate and nucleic acids. These in turn involve in various physio-biochemical process including P_N, gs, chlorophyll and carotenoid synthesis, NR and CA activities and absorption of nutrients. The enhanced physio-biochemical processes due to P supply could result in efficient cell division, cell enlargement and differentiation leading to production of fresh and dry mass hence higher values for the fresh weight and dry weight plant^{-1} (Table 1). These results corroborate with the findings of Khan *et al*. (2000), Naeem and Khan (2005, 2009) and Naeem *et al*. (2009) on other medicinal plants. The improvement in seed yield plant^{-1} on P application seems mainly due to increased number of pods plant^{-1} as seeds pod^{-1} and 100-seed weight were not affected by P fertilization (Table 1). Our correlation studies also revealed a positive and significant correlation of pods plant^{-1} with seed yield plant^{-1} (r=0.994). For pods plant^{-1}, it may be added that P could induce differentiation and promote translocation of food material resulted from the efficient physio-biochemical process. A beneficial effect of P application was also reported by Naeem and Khan (2005) and Naeem *et al*. (2009) on seed-yield of other medicinal plants.

The increase in seed-protein content might be ascribed to the increased N content in leaves that might have increased the amino acid synthesis and thereby could have improved seed-protein content via their translocation to seeds. Furthermore, P might have proved effective due to its assured availability and continuous utilization in the carbon skeleton and amino acid synthesis as well as in the synthesis of energy rich molecules such as adenosine triphosphate. This was perhaps responsible for the enhanced synthesis of protein during seed development. A strong significant and positive correlation of leaf N content with seed protein content (r = 0.989 at 120 DAS, r = 0.993 at 150 DAS, r = 0.990 at 180 DAS) further supports this view. A significant effect of P application on seed-protein content has also been reported by Naeem and Khan (2005, 2009) and Naeem et al. (2009) in case of other medicinal plants. The present study indicates that the P-deficient soil in this region of India may be one of the main causes of poor senna sophera yield as low P level was successfully ameliorated by its application to the soil. Application of 75 mg P kg^{-1} soil as potassium dihydrogen phosphate soil in pots proved to be the best for maximizing the productivity and quality of this important medicinal plant. The determined optimum P dose needs to be further examined under field conditions.

ACKNOWLEDGEMENTS

The financial support to one of us (M. Naeem) by the Science and Engineering Research Council, Department of Science & Technology, Government of India, (Project No. SR/FT/LS-003/2008) is gratefully acknowledged.

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