Pak. J. Agri. Sci. Vol. 36 (3-4), 1999

EFFECT OF AUXINS ON THE GROWTH AND YIELD OF RICE

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A field experiment was conducted at the Postgraduate Agricultural Research Station (PARS), University of Agriculture, Faisalabad to evaluate the effect of an auxin, indole-3- acetamide (IAM) and its precursor L-tryptophan (L-TRP), on the growth and yield of rice (cv. Basmati-385). Rice seedlings were treated with different levels of L-TRP (10^{-2} to 10^{-6} M) and IAM (10^{-3} to 10^{-9} M) by dipping the roots in respective solution for one hour just before transplanting them into the field. In case of control, roots were dipped in tap water for the same period of time. Both the pure auxin and its precursor significantly enhanced the yield and NPK contents of rice compared to untreated control. L-tryptophan application @ 10^{-5} M significantly increased the plant height (4.3%), paddy yield (42.9%), number of tillers (29.7%), and number of panicles (28.5%), compared to control. The same level of L-TRP also significantly improved NPK contents of rice.

Key words: auxins, indole-3-acetamide, L-tryptophan

INTRODUCTION

There are different auxins (indole-3-acetic acid, indole-3-acetamide, etc.) which have shown to be involved in a variety of plant growth and development responses. Indole-3-acetamide (IAM) is an intermediate product in the pathway of tryptophan (TRP) to indole-3-acetic acid (IAA). Tryptophan-2-monooxygenase and IAM hydrolase act in concert to produce IAA from TRP (White and Ziegler, 1991). Auxins are synthesized indigenously by plants, however, several studies demonstrated that plants can respond to exogenously applied auxins (Zelena et al., 1988; Park et al., 1992). This response may be due to the lack of sufficient endogenous auxins for optimal growth and development under suboptimal climatic and environmental conditions. An exogenous application of auxins may affect the endogenous hormonal pattern of the plant, either by supplementation of suboptimal levels or by interaction with the synthesis, translocation or inactivation of existing hormone levels (Arshad and Frankenberger, 1993). Kawaguchi et al. (1991) detected the enzymatic activity that converts IAM into IAA in rice. Auxin production in soil is the most active in the rhizosphere or at microsites where substrates and microorganisms are abundant (Rossi et al., 1984). Thus, substrate-derived auxins in the vicinity of plant roots may have a physiological role in the growth and development of plants.

In addition to higher plants, soil microbiota are also active producers of auxins particularly in the presence of L-TRP (Arshad and Frankenberger, 1993; Frankenberger and Arshad, 1995). Exogenous application of L-TRP to soils has been shown to result in elevated levels of auxins (Sarwar et al., 1992; Martens and Frankenberger, 1993). Present study was conducted to investigate the effect of exogenously applied auxin, IAM and its precursor L-TRP on growth and yield of rice.

MATERIALS AND METHODS

A field experiment was conducted at the Postgraduate Agricultural Research Station, University of Agriculture, Faisalabad to evaluate the effect of IAM and L-TRP application on the growth and yield of a rice cv. Basmati-385. Fertilizers NPK, as urea, single super phosphate and potassium sulfate were applied @ 114-27-51 kg ha^{-1}, respectively, with whole of P, K and half of N at the time of transplanting, while the remaining half at panicle initiation i.e. 35-40 days after transplanting. In addition to NPK, zinc sulfate @ 12.5 kg ha^{-1} was applied after 10 days of transplanting. Rice seedlings were transplanted by maintaining plant to plant and row to row distance of 23 cm in a sandy clay loam field having pHs, 7.31; ECe, 1.71 dS m^{-1}; total nitrogen, 0.05%; available phosphorus, 7.1 mg kg^{-1} soil and extractable K, 116 mg kg^{-1} soil. Seedling roots were washed with tap water and dipped in seven levels of IAM (10^{-3} to 10^{-9} M) and five levels of L-TRP (10^{-2} to 10^{-6} M) for one hour. In case of control, the seedlings were dipped in simple tap water for the same period of time. The treatments were replicated four times in randomized complete block design and canal water was used for irrigation. One square meter (1 m^2) area was harvested randomly from each treatment and different growth and yield parameters were recorded at maturity. The data obtained were subjected to Dunnett's test (Steel and Torrie, 1980)

Table 1. Effect of auxins on plant height, number of tillers hill·1, number of panicles hill·1 and 1000-grain weight of rice

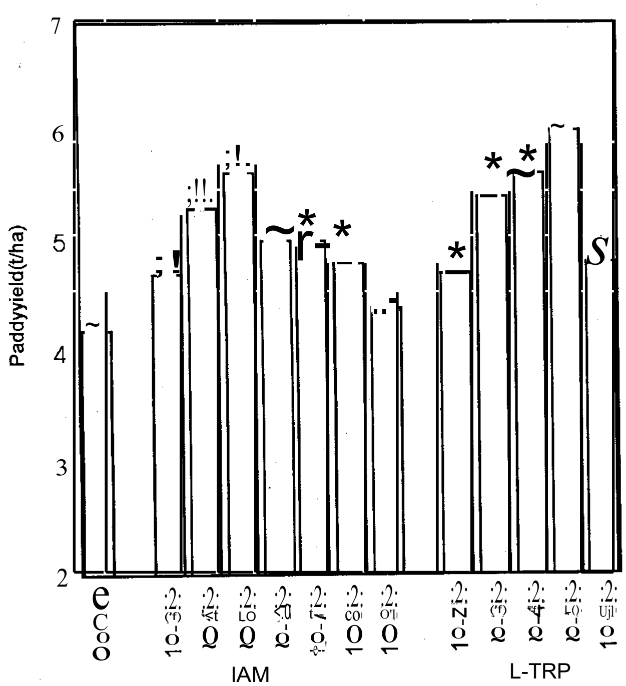
(Averaze of 4 repeats)

Treatment	Plant height (cm)	No. of tillers hill·1	No. of panicles hill·1	1000 -grain Wt. (g)
Control	93.1	14.5	13.0	19.52
10.3 M lAM	95.0*	17.6*	15.5*	19.33
10.4M lAM	95.6*	18.2*	16.0	20.07
10.5 M lAM	95.9*	18.5*	16.4*	20.53
10.6M lAM	93.6*	18.2*	16.1*	19.85
10-7 M lAM	93.4*	18.1*	16.0*	19.72
10'SM lAM	93.1	17.4*	15.4*	19.73
10-9M lAM	93.1	16.6*	14.0*	19.61
1O·2ML-TRP	93.2	15.0*	13.3*	19.60
10-3ML-TRP	93.5*	16.5*	14.5*	20.20
1O·4ML-TRP	94.2*	17.4*	14.6*	20.30
10.5 ML-TRP	97.0*	18.8*	16.7*	-20.81
10.6ML-TRP	94.3*	17.4*	14.9*	19.62

*Means significantly different from control at P = 0.05 according to Dunnett's test.

RESULTS

Results revealed that different growth and yield parameters of rice were significantly increased in response to the application of various levels of lAM and L-TRP. Paddy yield was significantly increased by all the levels of L-TRP and lAM except 10-9 M lAM (Fig. 1). Maximum paddy yield was observed where 10-5 M L-TRP was applied and it was 42.9%



*. Means significantly different from control at p=0,05 according to Dunnett's test

Fig.I. Effect of auxins on the paddy yield of rice

higher than control. Minimum increase in paddy yield (2.4% higher than control) was observed in response to 10-9 M lAM application. Some levels of lAM and L-TRP (Table 1) significantly increased plant height. Maximum plant height was observed where 10-5 M L-TRP was applied and it was 4.3% higher over control. Minimum increase in plant height was observed in response to 10-8 and 10-9 M lAM application.

Data given in Table 1 showed that increasing lAM concentrations (10-9-10-5 M) resulted in increased number of tillers hill-1. The highest number of tillers in case of auxin application was recorded with 10-5 M of lAM application which was 27.5% higher than control, whereas it is obvious from the data that decreasing L-TRP concentrations (10-2 to 10-5 M) resulted in the highest number of tillers hill-1 with 10-5 L-TRP application which was 29.7% higher than control. Minimum increase in number of tillers hill-1 (3.4% higher than control) was found where 10-2 M L-TRP was applied. Maximum number of panicles hill-1 were counted with L-TRP (10-5 M) which were 28.5% higher than control and differed significantly from untreated control. Application of L-TRP @ 10-2 M was found to be the least effective in increasing number of panicles hill-1 (2.3% higher than control). Data regarding 1000-grain weight (Table 1) revealed that lAM and L-TRP application had no significant effect on this parameter.

The highest increase in nitrogen percentage in straw (69.84% as compared to control) was found

Table 2. Effect of auxins on NPK concentrations in grain ~mdstraw of rice

(Average of 4 repeats)

Treatment	% In grain			% In straw		
	N	P	K	N	P	K
Control	0.63	,0.68	0.23	0,41	3.60	0.37
10^{-3} M IAM	0,75*	0.81*	0.27*	0,46*	4.75*	0,46*
10^{-4} M IAM	0.72*	0.77*	0.28*	0,48*	4.90*	0,47*
10^{-5} M IAM	0.87*	0.92*	0.28*	0,47*	4.65*	0,47*
10^{-6} M IAM	0.84*	0.89*	0.25*	0,44*	4.35*	0,44*
10^{-7} M IAM	0.81*	0.85*	0.28*	0,47*	4.90*	0,49*
10^{-8} M IAM	0.77*	0.81*	0.27*	0,46*	4.60*	0,45*
10^{-9} M IAM	0.70*	0.75*	0.27*	0,46*	4.45*	0,45*
10^{-2} M L-TRP	0.82*	0.84*	0.28*	0,48*	4.55*	0,45*
10^{-3} M L-TRP	0.87*	0.88*	0.27*	0,48*	4.85*	0,42*
10^{-4} M L-TRP	0.91*	0.95*	0.30*	0.53*	4.95*	0.50*
10^{-5} M L-TRP	1,07*	1,05*	0.34*	0.57*	5.10*	0.52*
10^{-6} M L-TRP	0.84*	0.89*	0.31*	0.53*	4.60*	0,43*

*Means significantly different from control at P = 0.05 according to Dunnett's test.

with the application of L-TRP @ 10^{-5} M (Table 2), whereas compared to the control, the lowest increase in nitrogen percentage (11.11%) in straw was found with the application of IAM @ 10^{-9} M. Maximum increase in nitrogen percentage in grain was 54.41% and it was observed with the application of L-TRP @ 10^{-5} M. Minimum increase in nitrogen percentage in grain (10.29% as compared to control) was observed with the application of IAM @ 10^{-9} M. Compared to the control, the maximum increase in phosphorus percentage in straw was 47.82 which was obtained with the application of L-TRP @ 10^{-5} M (Table 2), whereas minimum increase in phosphorus percentage in straw (8.69% as compared to control) was found with the application of IAM @ 10^{-6} M. Application of L-TRP @ 10^{-5} M gave maximum increase in the phosphorus percentage in grain (39.02 as compared to control), while compared to control IAM @ 10^{-6} M gave minimum increase (7.31%) in the phosphorus percentage in grain. Potassium percentage in straw and grain was found maximum (41,66 and 40.54 as compared to control respectively) with the application of L-TRP @ 10^{-5} M, whereas potassium percentage in straw and grain was minimum with the application of IAM @ 10^{-6} M and L-TRP @ 10^{-3} M (Table 2).

DISCUSSION

Indole-3-acetamide (IAM) is considered to play dual role in the plants. It can act as a hormone (auxin) or may serve as an immediate precursor of indole-3-acetic acid, IAA. Earlier studies confirmed that some of the intermediates of tryptophan (TRP) conversion into IAA-including IAM; tryptophol, also known as indole-3-ethanol, and tryptamine (TAM) also possess auxin activity (Arshad and Frankenberger, 1998). Application of various auxins (Indole-3-acetic acid, Indole-3- acetamide, Indole-3-butyric acid and Indole-3-lactic acid) to soil produced a physiological response by *Raphanus sativus* (Frankenberger et al., 1990). Kuo and Kosuge (1970) found that IAA was produced by *Pseudomonas syringae* pv. *Savastanoi* when supplied with IAM and it was the most effective precursor in IAA formation.

L-Tryptophan is a well established precursor of auxins in higher plants and for microbially derived auxins in pure cultura and soil (Frankenberger and Arshad, 1995). The effect of L-TRP on growth and yield of rice could be attributed to either auxin metabolites produced by the rhizosphere microflora which were subsequently taken up by plant roots or direct uptake of L-TRP by the plant roots with subsequent catabolism into auxins within the plant tissue and/or alteration in the balance of the rhizosphere microbial community in response to L-TRP addition which may affect growth and yield of rice. However, Martens and Frankenberger (1994) reported very poor uptake of labeled L-TRP compared with labeled IAA by wheat seedling roots. They also demonstrated poor endogenous conversion of exogenously applied labeled tryptophan into auxins by wheat seedlings grown under axenic environments. Addition of labeled 3_^{14}C-IAA to aseptic sterile and non-sterile soil resulted in assimilation and translocation of the label to the shoot tissues as amino acid conjugates of IAA (Martens and Frankenberger, 1992). This implies that auxins produced by the rhizosphere microflora derived from L-TRP could be taken up by the plant roots and may be translocated to the shoots resulting in a physiological response. So the physiological response could most likely be evoked by the auxins derived from microbial catabolism of L-TRP in the vicinity of rhizosphere. Application of fertilizers (NPK: 114- 27- 51 kg ha^{-1}) in this study rules out the possibility of nutritional effect of IAM and L-TRP.

Previous studies have shown that application of L-TRP had a significant positive effect on the growth and yield of corn, soybean and cotton (Sarwar and Frankenberger, 1994; Arshad et al., 1994, 1995) when applied to soil or sand. Frankenberger et al. (1990) compared the effect of L-TRP with known auxins (indole-3-acetic acid, indole-3-acetamide and indole-3-lactic acid) on growth and yield of radish and found that L-TRP was either equally effective or better than these pure auxins in terms of yield.

Conclusion: Results of this study demonstrated that the growth and yield of rice may be enhanced with the application of an auxin, IAM and its precursor L-TRP. Bioproduction of plant growth regulators such as auxins in soil as a result of microbial activity from the added precursor may be recognised as having a potential influence on plant growth and development. Further studies are needed to irivestigate factors affecting the microbial production of auxins such as their distribution and stability in soil and their direct uptake by plants.

REFERENCES

Arshad, M. and W.T. Frankenberger, Jr. 1993. Microbial production of plant growth regulators. In Soil Microbial Ecology (Ed. F.B. Metting Jr.), pp.307-347. Marcel Dekker Inc., New York, USA.

Arshad, M., M. Javed and A Hussain. 1994. Response of soybean *(Glycine max)* to soil applied precursors of phytohormones. PGRSA Quarterly, 22:109-115.

Arshad, M., A Hussain and A. Shakoor. 1995. Effect of soil applied L-tryptophan on growth and chemical composition of cotton. J. Plant Nutr. 18:317-329.

Arshad, M. and W. T Frankenberger, Jr. 1998. Plant growth-regulating substances in the rhizosphere: Microbial production and functions. Adv. Agron. 62:45-151.

Frankenberger, W.T. Jr., AC. Chang and M. Arshad. 1990. Response of *Raphanus satiuus* to auxin precursor L-tryptophan applied to soil. Plant Soil, 129:235-241.

Frankenberger, W.T.Jr. and M. Arshad. 1995. Phytohormones in Soils: Microbial production and function. Marcel Dekker. Inc., New York, USA.

Kawaguchi, M., M. Kobayashi, A Sakurai and K. Syono. 1991. The presence of enzyme that converts indole-3-acetamide into IAA in the wild and cultivated rice. Plant Cell Physiol. 34:143-149.

Kuo, T.T. and T. Kosuge. 1970. Role of aminotransferase and indole-3-pyruvic acid in the synthesis of indole-3-acetic acid in *Pseudomonas sauastanoi.* J. Gen. Appl. Microbiol. 16: 191-204.

Martens, D.A and W.T. Frankenberger, Jr. 1992. Assimilation of 3-C-indole, acetic acid and tryptophan by wheat from nutrient media. P. 99-100. In Proc. 19th Annual Meeting Plant Growth Regulator Society of America, San Francisco, CA, USA, July 17-20.

Martens, D.A and W.T. Frankenberger, Jr. J993. Metabolism of tryptophan in soil. Soil Biol. Biochem.25:1679-1687.

Martens, D.A and W.T. Frankenberger, Jr. 1994. Assimilation of exogenous 2-^{14}C-indole acetic acid and 3_^{14}C-tryptophan exposed to roots of three wheat varieties. Plant Soil, 166: 281-290.

Park, .H., J.H. Yoo and B.G.Cho. 1992. Growth response of Panar ginseng to various growth regulators. In Plant Hormones and their Role in Plant Growth and Development (Ed. P.J. Davies), pp. 24-42. Martinus Nijhoff Publ. Dordrecht, The Netherlands.

Rossi, W.A, A Grappelli and W. Pietrosanti. 1984. Phytohormones in soil after atrazine application. Folia Microbial. 29:325-329.

Sarwar,' M., M. Arshad, D.A Martens and W.T. Frankenberger, Jr. 1992. Tryptophan dependent biosynthesis of auxins in soil. Plant Soil, 147:207-215.

Sarwar, M. and W.T. Frankenberger Jr. 1994. Influence of L-TRP and auxins applied to rhizosphere on the vegetative growth of *Zea mays* L. Plant Soil, 160:97-104.

Steel, R.G.D. and J.H. Torrie. 1980. Principles and Procedures of Statistics. McGraw Hill Book Co. Inc., New York, USA.

White, F.F. and S.F. Ziegler. 1991. Clonig of the genes for indoleacetic acid synthesis for *Pseudomonas syringae* pv. *Syringae*. Mol. Plant Microbe Interact. 4: 207-210.

Zelena, E., M. Kutacek and V. Germak. 1988. Fate of root applied indolyl acetic acid and its influence on the growth of intact plant. In Physiology and Biochemistry of Auxins in Plants, PP. 371-376. SPB Academic Publ., Czechoslovakia.