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Implant of Foliar Sprays of Polyamine (Putrescine) and NAA On Chemical and Biochemical Parameters and Yield of Pigeonpea

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ABSTRACT

An experiment was conducted during the kharif season of 2016-2017 at farm of Botany section, College of Agriculture, Nagpur, to study the effect of foliar sprays of putrescine and NAA on chemical and biochemical parameters and yield of pigeonpea cv. PKV- Tara. The experiment was laid out in randomized block design with eighteen treatments and three replications. The different treatments tried were 25 and 50 ppm NAA and 25, 50, 75, 100 and 125 ppm putrescine alone or in combination. One control (water spray) treatment was also taken. Spraying of putrescine and NAA alone and in combination were applied at 45 and 65 DAS. Foliar sprays of 50 ppm NAA + 100 ppm putrescine followed by 50 ppm NAA + 75 ppm putrescine significantly enhanced nitrogen, phosphorus, potassium, chlorophyll in leaf, protein content in seed. Considering the Benefit: Cost ratio 50 ppm NAA was found more economical having B:C ratio of 2.67 as compared to 2.26 in control.
Key words: Pigeonpea, putrescine, NAA, foliar application, chemical and biochemical parameters, yield

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INTRODUCTION

Pigeonpea is an important grain legume of the semiarid tropics and forms a significant component of the diet of vegetarians. Pigeonpea (*Cajanuscajan* L. Millsp.) is a important legume and belongs to family *Leguminaceae* and genus Cajanus. According to FAO pigeonpea is also known as Red gram, tur, arhar, dal (India).Its drought tolerance and the ability to use residual moisture during the dry season make it an importance crop. Area under pigeonpea during 2015-16 in India is 3.9 million ha, production 3.31 million tonnes and productivity 914 kg ha^{-1}.

Pigeonpea is grown throughout the tropical and subtropical countries of the world especially in South Asia, Eastern and Southern Africa, Latin America, Caribbean countries and Australia. Interest in this crop is growing in many countries because of its multiple uses as source of food, livestock fodder and also improves soil fertility. Pigeonpea is nutritionally important as it contains protein 22.3 %, fat 1.7 %, calcium 7.3 mg, thiamine 0.45 mg, riboflavin 0.19 mg, niacin 2.9 mg. Besides this they are also the sources of minerals and some vitamins.

The diamine putrescine occurred widely in the higher plants. It was suggested to be involved in a variety of growth and developmental processes such as cell division (Bueno and Matilla, 1992), fruit set and growth (Biasi e*t al*., 1991) and senescence (Kao, 1994). Putrescine treatments significantly increased fresh and dry weights of bean plants. Putrescine at 10^{-5} M increased grain and biological yield and grain index of wheat plant (Gupta *et al*., 2003).

NAA (Naphthalene Acetic Acid) is the synthetic auxin with the identical properties to that naturally occurring auxin. It prevents formation of abscission layer and there by flower drop. It was observed that the growth regulators are involved in the direct transport of assimilates from source to sink (Sharma *et al*., 1989).

Considering the above facts present investigation was undertaken to study the responses of putrescine and NAA on chemical and biochemical parameters and yield of pigeonpea.

MATERIALS AND METHODS

Considering the above fact present work was undertaken to study the response of putrescine and NAA on chemical and biochemical parameters and yield of pigeonpea. Experiment was laid out in randomized block design with eighteen treatments and three replications. Plot size of individual treatment was gross 4.20 m x 4.40 m and net 3.0 m x 4.0 m. Seeds were sown at the rate of 20 kg ha^{-1} by dibbling method at spacing of 60 cm x 20 cm on 1st July 2016. Treatments comprised of control (T_1), 25 ppm NAA (T_2), 50 ppm NAA (T_3), 25ppm putrescine (T_4), 50 ppm putrescine (T_5), 75 ppm putrescine (T_6), 100 ppm putrescine (T_7), 125 ppm putrescine (T_8), 25 ppm NAA + 25 ppm putrescine (T_9), 25 ppm NAA + 50 ppm putrescine (T_{10}), 25 ppm NAA + 75 ppm putrescine (T_{11}), 25 ppm NAA + 100 ppm putrescine (T_{12}), 25 ppm NAA + 125 ppm putrescine (T_{13}), 50 ppm NAA + 25 ppm putrescine (T_{14}), 50 ppm NAA + 50 ppm putrescine (T_{15}), 50 ppm NAA + 75 ppm putrescine (T_{16}), 50 ppm NAA + 100 ppm putrescine (T_{17}) and 50 ppm NAA + 125 ppm putrescine (T_{18}). The foliar application of putrescine and NAA was given at two stages i.e. at 45 and 65 DAS on pigeonpea. Observations chemical and biochemical parameters viz., nitrogen, phosphorus, potassium, chlorophyll in leaf, protein content in seed, yield and yield contributing parameters were recorded at 45, 65, 85 and 105 DAS and seed yield ha^{-1} were also recorded after harvesting. Percent increase and B:C were also calculated. The crop was kept free from disease and pest during the growth period. Harvesting was undertaken after the crop attained maturity. Data were analysed by statistical method suggested by Panse and Sukhatme (1954).

RESULTS AND DISCUSSION

Leaf nitrogen content

Nitrogen is key component in mineral fertilizers and has more influence on plant growth, appearance and fruit production or quality than any other essential elements. Nitrogen is an important constituent of protein and protoplasm and essential for the growth of plants.

Leaf nitrogen at 65, 85, 105 DAS was significantly enhanced by the treatments 50 ppm NAA + 100 ppm putrescine (T_{17}) and 50 ppm NAA + 75 ppm putrescine (T_{16}) followed by treatments 50 ppm NAA + 50 ppm putrescine (T_{15}), 50 ppm NAA + 25 ppm putrescine (T_{14}), 25 ppm NAA + 100 ppm putrescine (T_{12}), 50 ppm NAA (T_3), 100 ppm putrescine (T_7), 25 ppm NAA + 75 ppm putrescine (T_{11}). Treatment 25 ppm NAA + 125 ppm putrescine (T_{13}) also found maximum nitrogen content in leaves over control and other treatments.

Deotale *et al.* (2016) carried out a field experiment to investigate the effect of different concentrations of putrescine and IBA (50, 75, 100, 125 and 150 ppm each) with one control on chemical, biochemical, yield and yield contributing characters of soybean and reported that two foliar sprays of 100 ppm putrescine and 100 ppm IBA at two stages i.e. before flowering and 10 days after flowering were found to be most effective in enhancing nitrogen content in leaves.

Leaf phosphorus content

Phosphorus is an important constituent of protoplasm and nucleic acid and protein also, it is essential for the formation of grain.

At 65, 85, 105 DAS treatments 50 ppm NAA + 100 ppm putrescine (T_{17}), 50 ppm NAA + 75 ppm putrescine (T_{16}), 50 ppm NAA + 50 ppm putrescine (T_{15}), 50 ppm NAA + 25 ppm putrescine (T_{14}) and 25 ppm NAA + 100 ppm putrescine (T_{12}), 50 ppm NAA (T_3), 100 ppm putrescine (T_7), 25 ppm NAA + 75 ppm putrescine (T_{11}) and 25 ppm NAA + 125 ppm putrescine (T_{13}) were increased leaf phosphorus content over control and rest of the treatments under study.

Singh *et al*. (2015) observed that foliar application of 50 ppm NAA significantly increased leaf phosphorus content of seed and straw in fenugreek. Similarly phosphorus uptake was also found significantly enhanced by the application of NAA 50 ppm over control.

Leaf potassium content

Potassium is an essential macronutrient for plants involved in many physiological processes. It is important for crop yield as well as for the quality of edible parts of crops. Although potassium is not assimilated into organic matter, potassium deficiency has a strong impact on plant metabolism.

Potassium content at 65, 85, 105 DAS was significantly maximum in treatments 50 ppm NAA + 100 ppm putrescine (T_{17}), 50 ppm NAA + 75 ppm putrescine (T_{16}), 50 ppm NAA + 50 ppm putrescine (T_{15}), 50 ppm NAA + 25 ppm putrescine (T_{14}), 25 ppm NAA + 100 ppm putrescine (T_{12}), 50 ppm NAA (T_3), 100 ppm putrescine (T_7), 25 ppm NAA + 75 ppm putrescine (T_{11}), 25 ppm NAA + 125 ppm putrescine (T_{13}) in a descending manner when compared over control and rest of treatments.

It was observed that potassium content increased upto 65 DAS but thereafter, at 85 DAS and 105 DAS stages it was decreased. The decrease in potassium content might be due to diversion of potassium towards developing pods of pigeonpea. In young stage plant may be able to uptake nutrient more readily than the older one. Potassium in leaf tissues was found higher at initial two stages of observations, mainly due to application of putrescine and NAA and it might be because of relatively higher physiological activities as the plant tissues were younger during these stages.

Wagh (2015) conducted a field experiment to evaluate the effect of putrescine and IBA both applied @ 0, 50, 75, 100, 125 and 150 ppm on soybean at 30 and 45 DAS. Results showed that foliar sprays of putrescine and IBA @100 ppm significantly enhanced potassium content in leaves.

Protein content in seeds

Although quality of crop products such as oil, protein and sucrose content and appearance are genetically controlled. The nutrition of plants can have considerable impact on the expression of quality. It is therefore, essential to judiciously take care on the nutrient supply at grain formation stage.

Treatment considering for evaluation of this study were found significantly superior over control. However, 50 ppm NAA + 100 ppm putrescine (T_{17}) recorded the highest protein content i.e. 23.02%, while control (T_1) treatment recorded minimum i.e. 20.56%. Data indicated that protein content was significantly increased in treatment 50 ppm NAA + 100 ppm putrescine (T_{17}) followed by treatments 50 ppm NAA + 75 ppm putrescine (T_{16}), 50 ppm NAA + 50 ppm putrescine (T_{15}), 50 ppm NAA + 25 ppm putrescine (T_{14}), 25 ppm NAA + 100 ppm putrescine (T_{12}), 50 ppm NAA (T_3), 100 ppm putrescine (T_7), 25 ppm NAA + 75 ppm putrescine (T_{11}), 25 ppm NAA + 125 ppm putrescine (T_{13}), 25 ppm NAA + 50 ppm putrescine (T_{10}), 25 ppm NAA + 25 ppm putrescine (T_9), 25 ppm putrescine (T_4) and 50 ppm putrescine (T_5) when compared with treatment T_1 (control) and remaining treatments.

Pigeonpea plants have high nitrogen requirement for seed production. Major part of nitrogen is accumulated in the seed during pod filling stage. Nitrogen is key component in mineral fertilizers and has more influence on plant growth, appearance and fruit production / quality than any other element.

Medhi *et al.* (2014) reported that application of growth regulators (IAA 25 ppm, NAA 50 ppm, ascorbic acid 25 ppm, ethrel 250 ppm and gibberellic acid 30 ppm) and phosphorus levels (20, 40 and 60 kg ha^1) significantly improved nutritional parameters of seed viz., total soluble, starch, protein and free amino acid content.

Chlorophyll content in leaves

Chlorophyll is the green pigment present in leaf and playing main role in the photosynthetic activity and thereby increasing the weight of the plant. The greenness of the leaf is generally considered to be a parameter contributing to yielding ability of the cultivar. Leaves constitute most important aerial organ of the plants, playing a major role in the anabolic activities by means of the so called 'green pigments or chlorophyll' is the sole medium of the photosynthetic progress which in turn is the major synthesis pathway operatives in plants.

Data indicated that, at the 65, 85, 105 DAS the highest chlorophyll content was recorded in treatment 50 ppm NAA + 100 ppm putrescine (T_{17}) followed by treatments 50 ppm NAA + 75 ppm putrescine (T_{16}), 50 ppm NAA + 50 ppm putrescine (T_{15}), 50 ppm NAA + 25 ppm putrescine (T_{14}), 25 ppm NAA + 100 ppm putrescine (T_{12}), 50 ppm NAA (T_3), 100 ppm putrescine (T_7) and 25 ppm NAA + 75 ppm putrescine (T_{11}) when compared with control and rest of the treatments.

Chlorophyll content in leaves was increased upto 65 DAS but thereafter, it decreased. Data regarding chlorophyll content in leaves at 45 DAS was found to be non significant. Putrescine or NAA treatments might retard chlorophyll destruction and increase their biosynthesis or stabilize the thylakoid membrane. Polyamines may retard senescence and chlorophyll loss by altering the stability and permeability of membranes and protecting chloroplast from senescing (Gonzalez-Aguilar *et al*., 1997).

Deotale *et al*. (2016) tested different concentrations of putrescine and IBA (50, 75, 100, 125 and 150 ppm each) with one control on biochemical parameters of soybean and reported that two foliar sprays of 100 ppm putrescine and 100 ppm IBA at two stages i.e. before flowering and 10 days after flowering were found to be most effective in enhancing chlorophyll content in leaves.

Yield parameters

Seeds yield is the economic yield which is final result of physiological activities of plant. Economic yield is the part of biomass that is converted into economic product. (Nichiporovic, 1960).

Seed yield is influenced by chemical and biochemical parameters such as nitrogen, phosphorus, potassium, chlorophyll in leaf, protein content in seed and seed yield ha^{-1} were also recorded after harvesting. Source–sink relation contributes to the seed / grain yield. It includes phloem loading at source (leaf) and unloading at sink (seed and fruit) by which the economic part will be getting the assimilates synthesized by photosynthesis. Partitioning of assimilate in the plant during reproductive development is important for flower, fruit and seeds.

The maximum seed yield hectare^{-1} was recorded in treatment 50 ppm NAA + 100 ppm putrescine (T_{17}). The range of increase in seed yield hectare^{-1} was 15.43 q in treatment T_1 (control) to 24.33 g, 2.43 kg and 20.27 q in treatment recames 50 ppm NAA + 100 ppm putrescine (T_{17}). Significantly maximum seed yield ha^{-1} was recorded in treatments 50 ppm NAA + 100 ppm putrescine (T_{17}) followed by treatments 50 ppm NAA + 75 ppm putrescine (T_{16}), 50 ppm NAA + 50 ppm putrescine (T_{15}), 50 ppm NAA + 25 ppm putrescine (T_{14}), 25 ppm NAA + 100 ppm putrescine (T_{12}), 50 ppm NAA (T_3), 100 ppm putrescine (T_7) when compared with control and rest of the treatments. Treatments 25 ppm NAA + 75 ppm putrescine (T_{11}), 25 ppm NAA + 125 ppm putrescine (T_{13}) and 25 ppm NAA + 50 ppm putrescine (T_{10}) also significantly enhanced seed yield ha^{-1} as compared to control and rest of the treatments.

Kapase *et al*. (2014) reported that foliar application of humic acid through vermicompost wash and NAA on chickpea and reported that foliar spray of 50 ppm NAA + 400 ppm HA through VCW followed by 50 ppm NAA and 300 ppm HA through VCW significantly increased seed yield ha^1.

Harvest index (HI)

Significantly maximum harvest index was recorded in treatment 50 ppm NAA + 100 ppm putrescine (T_{17}) and minimum in control. The range of increased harvest index was 27.30 in control and 35.82 in above treatment.

Treatments 50 ppm NAA + 100 ppm putrescine (T_{17}), 50 ppm NAA + 75 ppm putrescine (T_{16}), 50 ppm NAA + 50 ppm putrescine (T_{15}) and 50 ppm NAA + 25 ppm putrescine (T_{14}) increased harvest index significantly over control and rest of the treatments. Similarly treatment 25 ppm NAA + 100 ppm putrescine (T_{12}) also increased the harvest index significantly over control and remaining treatments.

El-Bassiouny *et al*. (2008) tested arginine and putrescine (0.0, 0.6, 1.25, 2.5 and 5 mM) at three physiological stages (vegetative, 30 DAS; just before emergence of main spike, 60 DAS and during grain filling, 90 DAS) and reported that foliar application of 2.5 mM arginine and putrescine on wheat significantly increased straw yield and harvest index when applied at 30 or 60 DAS over control.

Harvest index is the proportion of biological yield represented by economic yield. It is the coefficient of effectiveness or the migration coefficient. Harvest index reflects the proportion of assimilate distribution between the economic yield and total biomass (Donald and Hamblin, 1976). Increase in harvest index might be the result of coordinated interplay of growth and development characters.

The analysis of B:C ratio due to expenditure incurred under different treatments of putrescine and NAA revealed that highest Benefit:Cost ratio was calculated in treatment (T_3) 50 ppm NAA (2.67) followed by treatments (T_{13}), 50 ppm NAA + 25 ppm putrescine (2.46) and (T_2) 25 ppm NAA (2.34) as compared to 2.26 for control (T_1).

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Table. 1. Effect of putrescine and NAA on chemical and biochemical parameters.

Treatments	Leaf nitrogen content (%)				Leaf phosphorus content (%)				Leaf potassium content (%)			
	45 DAS	65 DAS	85 DAS	105 DAS	45 DAS	65 DAS	85 DAS	105 DAS	45 DAS	65 DAS	85 DAS	105 DAS
T_1 (Control)	2.154	3.114	2.918	2.61	0.295	0.356	0.324	0.278	0.796	0.73	0.614	0.561
T_2 (25 ppm NAA)	2.378	3.356	3.146	2.841	0.309	0.378	0.332	0.284	0.71	0.769	0.628	0.576
T_3 (50 ppm NAA)	2.694	4.135	3.427	3.414	0.367	0.421	0.382	0.33	0.913	0.848	0.741	0.65
T_4 (25 ppm Putrescine)	2.467	3.613	3.247	3.054	0.338	0.398	0.352	0.304	0.854	0.798	0.659	0.597
T_5 (50 ppm Putrescine)	2.458	3.563	3.215	3.016	0.331	0.392	0.348	0.299	0.835	0.784	0.653	0.594
T_6 (75 ppm Putrescine)	2.412	3.478	3.185	2.971	0.323	0.389	0.343	0.295	0.726	0.78	0.642	0.588
T_7 (100 ppm Putrescine)	2.689	4.107	3.392	3.394	0.363	0.417	0.376	0.327	0.905	0.832	0.736	0.636
T_8 (125 ppm Putrescine)	2.312	3.223	3.057	2.823	0.302	0.369	0.327	0.279	0.709	0.765	0.619	0.57
T_9 (25 ppm NAA + 25 ppm Putrescine)	2.53	3.846	3.262	3.131	0.345	0.4	0.359	0.309	0.867	0.803	0.662	0.608
T_{10} (25 ppm NAA + 50 ppm Putrescine)	2.587	3.938	3.281	3.143	0.348	0.405	0.361	0.315	0.874	0.812	0.674	0.611
T_{11} (25 ppm NAA + 75 ppm Putrescine)	2.646	4.076	3.378	3.234	0.359	0.412	0.373	0.322	.0.889	0.826	0.718	0.629
T_{12} (25 ppm NAA + 100 ppm Putrescine)	2.723	4.244	3.448	3.447	0.372	0.425	0.387	0.346	0.936	0.855	0.752	0.665
T_{13} (25 ppm NAA + 125 ppm Putrescine)	2.645	4.053	3.334	3.212	0.352	0.409	0.367	0.317	0.887	0.82	0.71	0.617
T_{14} (50 ppm NAA + 25 ppm Putrescine)	2.782	4.263	3.486	3.474	0.379	0.432	0.394	0.354	0.939	0.86	0.767	0.687
T_{15} (50 ppm NAA + 50 ppm Putrescine)	2.828	4.579	3.551	3.486	0.392	0.438	0.398	0.359	0.943	0.879	0.784	0.703
T_{16} (50 ppm NAA + 75 ppm Putrescine)	2.873	4.712	3.614	3.488	0.412	0.441	0.408	0.363	0.951	0.892	0.792	0.71
T_{17} (50 ppm NAA + 100 ppm Putrescine)	2.861	4.82	3.852	3.546	0.428	0.452	0.415	0.374	0.991	0.902	0.812	0.715
T_{18} (50 ppm NAA + 125 ppm Putrescine)	2.379	3.431	3.173	2.953	0.316	0.385	0.339	0.287	0.712	0.772	0.635	0.582
SE (m) ±	0.471	0.25	0.155	0.138	0.009	0.015	0.013	0.0098	0.019	0.028	0.034	0.025
CD at 5%	-	0.746	0.463	0.413	-	0.043	0.038	0.029	-	0.082	0.102	0.072

Table. 2. Effect of putrescine and NAA on chlorophyll and yield parameters.

Treatments	Leaf chlorophyll content (mg g-1)				Seed yield ha^{-1}	Harvest index	B:C ratio
	45 DAS	65 DAS	85 DAS	105 DAS			
T_1 (Control)	0.881	1.195	1.19	0.765	15.43	27.3	2.26
T_2 (25 ppm NAA)	0.902	1.31	1.238	0.816	16.04	28.02	2.35
T_3 (50 ppm NAA)	1.054	1.407	1.38	0.88	18.33	30.93	2.69
T_4 (25 ppm Putrescine)	0.967	1.341	1.275	0.845	17.63	28.84	2.53
T_5 (50 ppm Putrescine)	0.945	1.328	1.267	0.84	17.05	28.68	2.39
T_6 (75 ppm Putrescine)	0.921	1.323	1.259	0.837	16.75	28.42	2.3
T_7 (100 ppm Putrescine)	1.027	1.4	1.332	0.876	18.23	30.45	2.45
T_8 (125 ppm Putrescine)	0.889	1.28	1.227	0.792	15.83	27.95	2.08
T_9 (25 ppm NAA + 25 ppm Putrescine)	0.971	1.346	1.279	0.852	17.73	29.21	2.5
T_{10} (25 ppm NAA + 50 ppm Putrescine)	0.975	1.364	1.284	0.861	17.76	29.76	2.49
T_{11} (25 ppm NAA + 75 ppm Putrescine)	1.013	1.392	1.318	0.873	17.94	30.19	2.46
T_{12} (25 ppm NAA + 100 ppm Putrescine)	1.072	1.42	1.49	0.882	18.46	32.22	2.48
T_{13} (25 ppm NAA + 125 ppm	0.982	1.385	1.302	0.863	17.83	29.9	2.34

Putrescine)							
T_{14} (50 ppm NAA + 25 ppm Putrescine)	1.148	1.512	1.465	0.907	18.87	33.45	2.7
T_{15} (50 ppm NAA + 50 ppm Putrescine)	1.159	1.512	1.503	0.923	19.52	34.28	2.73
T_{16} (50 ppm NAA + 75 ppm Putrescine)	1.236	1.543	1.531	0.964	20.1	35.39	2.75
T_{17} (50 ppm NAA + 100 ppm Putrescine)	1.251	1.569	1.557	0.978	20.27	35.82	2.72
T_{18} (50 ppm NAA + 125 ppm Putrescine)	0.913	1.32	1.24	0.823	16.4	28.1	2.15
SE (m) ±	0.064	0.061	0.077	0.034	0.755	1.131	-
CD at 5%	-	0.18	0.232	0.102	2.252	3.373	-

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