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Effect of some phenolic acids on quality and yield of chickpea seeds

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Abstract. Exogenous application of 1-amino; 4-sulphonate, β-naphthol; 8-amino; 3–6 disulphonate, γ-naphthol; 1, 3-dihydroxybenzene and 4, 6-Bis (diazonaphthalene sulphonate-resorcinol) (5, 20, 50 ppm) increased number of pods per plant, number of seeds/pod and improved the yield (kg/ha) in chickpea. Some of the compounds enhanced total free amino acids and soluble protein and total soluble sugars. The effects of the phenolic acids on growth and development were independent of their structural configuration.

Keywords. Phenolic compounds; yield; quality; *Cicer arietinum*.

1. Introduction

India produces 74·58% of the total world production of chickpea, and has 75·52% of the total world acreage under chickpea (FAO 1983). The average yields of chickpea in India are very low and often uncertain due to pathological and physiological constraints. The use of plant growth regulators in general and phenolic compounds in particular in regulating morphogenetic differentiation and alleviating various physiological disorders causative of low and uncertain yields in different crop plants is well documented (Nickel 1983; Malik *et al* 1986). Besides quantitative increase, there is also the need for enhancing the nutritional value of chickpeas. Malik *et al* (1986) reported that 4 phenolic compounds, viz. H-acid, 1, 2, 4-acid, resorcinol and RD-brown, were highly effective in improving yield and nutritional quality of some peanut varieties. The present investigation was carried out to determine the effects of some low-cost phenolic acids on quality and yield of mature chickpea seeds.

2. Material and methods

Chickpea (*Cicer arietinum* L.) (GL-769) was sown in the field area of the Botany Department during 1983 with 3 replications of each treatment having a plot size of 4·5 × 3 m. The crop was raised according to the recommended practices for fertilizers, irrigation and plant protection measures (package of practices, 1983, PAU, Ludhiana). Two sprays were given—one at the time of flower initiation, i.e. 90 days after sowing and the second after 15 days of first spray of 5, 20, 50 ppm concentrations of different phenolic compounds (figure 1). Controls consisted of spraying with distilled water alone.

The effect of phenols on yield contributing parameters was computed on the basis of the following parameters recorded at the harvest time from 5 randomly selected plants from each treatment. The data on number of pods/plant at harvest time; number of seeds/pod taken from 10 pods from 5 randomly selected plants; 1000-seed weight selected after harvesting from each replication recorded in grams; and grain yield recorded from net area harvested and expressed as kilograms per hectare were

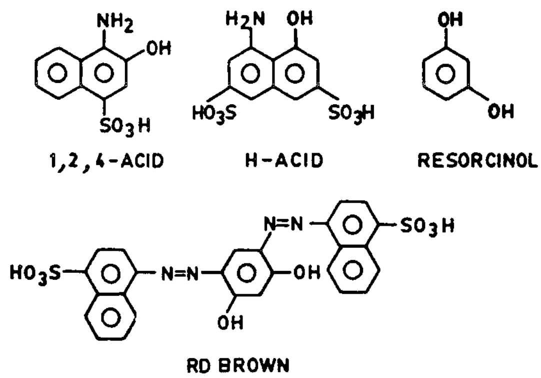

Figure 1. Phenolic compounds.

computed. Experimental plots were sprayed with a foot-sprayer of 400 l of solution per hectare. Five plants were selected from each of 3 replicated plots at harvest time for recording the data.

For ascertaining the quality of seeds at harvest time (49 days after anthesis), several biochemical parameters of mature whole seeds were analyzed according to standard spectrometric techniques, e.g. total soluble proteins (Lowry *et al* 1951); total free amino acids (Lee and Takahashi 1966) and starch and total soluble sugars (Loews 1952) were estimated.

For every estimation, 15 mg of dry material was used and a mean of 3 replicate observations was recorded. The details of phenolic acids used are given in table 1. Solutions of the acids were prepared by dissolving in a few drops of ethanol and then the final volume was adjusted with water.

3. Results and discussion

The data given in table 2 indicate significant differences between the controls and treatments in regard to both qualitative as well as yield contributing parameters. Table 2 shows that all the phenolic acids at all concentrations used significantly increased pod number per plant, except 5 ppm of RD-brown and resorcinol. The highest concentration (50 ppm) was most effective, except in resorcinol where 20 ppm gave the maximum number of pods. The data in table 2 shows that higher concentration (50 ppm) increased the number of seeds per pod in all the phenolic acids but the increase was non-significant. Table 2 also indicates non-significant differences among different treatments for 1000 seed weight. All the phenolic acids, at all the tried concentrations, improved the yield level significantly. On the whole, H-acid (20, 50 ppm) and 1, 2, 4-acid (50 ppm) showed the highest increment in yield compared with all other treatments.

Compared with the controls, plants sprayed with H-acid, resorcinol (5 ppm), RD-brown (5 ppm) and 1, 2, 4-acid (50 ppm) had increased content of free amino acids in their seeds. H-Acid (5 and 20 ppm), resorcinol (5, 20, 50 ppm) and RD-brown (5 and 20 ppm) significantly increased the protein content in the seed (table 3). Among the 3 phenols, RD-brown (5 ppm) was most effective. Compared with phenolic acid treatments [(1, 2, 4-acid; H-acid, resorcinol (5, 20, 50 ppm) and RD-brown (5 and 20 ppm)], the seeds of control plants had lower contents of sugars (mg g^{-1} dry

Table 1. Chemistry of 4 compounds used.

Chemical name	Common name	Concentration used (ppm)	Molecular weight
Monophenols			
1-Amino; 4-sulphonate, β-naphthol	1, 2, 4-acid	5, 20, 50	239
8-Amino; 3–6 disulphonate, γ-naphthol	H-acid	5, 20, 50	319
Diphenols			
1, 3-Dihydroxy benzene	Resorcinol	5, 20, 50	710
4, 6-Bis (Diazonaphthalene sulphonate-resorcinol)	RD-Brown	5, 20, 50	622

Table 2. Effect of phenols on yield contributing parameters in chickpea.

Treatment (ppm)		Number of pods/plant	Number of seeds/pod	Thousand seed wt. (g)	Yield kg/hectare
Control		44·3	2·6	144·07	1185
1, 2, 4-Acid	5	48·6	2·2	174·21	1445
	20	50·2	2·9	165·88	1659
	50	55·4	3·1	151·11	1908
H-Acid	5	46·5	2·5	148·85	1460
	20	60·2	1·8	169·66	1979
	50	68·4	3·4	180·71	2015
Resorcinol	5	39·3	1·5	158·33	1659
	20	62·5	2·6	153·13	1397
	50	47·1	2·9	161·11	1485
RD-Brown	5	42·5	2·7	164·58	1266
	20	53·8	3·4	162·16	1604
	50	57·6	3·3	179·03	1815
CD at 5%		2·71	NS	NS	6·85

weight). Resorcinol (50 ppm) recorded the highest content of soluble sugars in the seeds. On the contrary, starch content of seeds decreased in most treatments, except H-acid (20 ppm), resorcinol (5 ppm) and RD-brown (20 and 50 ppm). The maximum increase was noticed with RD-brown (50 ppm).

The phenolic acids had a promoting effect on yield per unit area. Yield (kg per hectare) was notably high in 1, 2, 4-acid (50 ppm), H-acid (20 and 50 ppm) and RD-brown (50 ppm) treatments. Correspondingly, the average seed weight (1000-seed weight) was also higher in all the treatments than in control. Singh *et al* (1980) used α- and β-naphthol, salicylic acid, caffeic acid in chickpea and noticed increase in flowers/plant and number of pods per plant. Nanda *et al* (1976) reported the involvement of different phenols and their synergistic effect with gibberellic acid on flowering. Notably, 1, 2, 4-acid (5 ppm), H-acid (50 ppm) and RD-brown (50 ppm) were highly promotive. The average number of seeds per pod was promoted by all the treatments and increased with increasing concentrations, except with H-acid (20 ppm), resorcinol (5 ppm) and 1, 2, 4-acid (5 ppm). The number of pods per plant was enhanced with increasing concentration of all the substances; of these, H-acid (50 ppm) was most effective. Clearly, increase in yield by phenolic acids was quite

Table 3. Effect of phenols on some biochemical (seed quality mg/g dry weight) parameters in mature chickpea seeds.

Treatment (ppm)		Soluble proteins	Free amino acids	Starch	Soluble sugars
Control		144·69	15·02	175·5	28·0
1, 2, 4-Acid	5	120·02	11·54	165·0	38·5
	20	144·71	18·40	140·0	44·0
	50	129·00	26·15	135·0	38·0
H-Acid	5	168·67	23·30	165·0	39·0
	20	169·39	30·21	230·0	28·0
	50	145·40	35·90	110·0	30·5
Resorcinol	5	157·41	20·02	245·5	36·5
	20	188·09	13·35	125·0	26·5
	50	199·73	12·84	180·5	48·0
RD-Brown	5	219·02	25·68	180·5	35·0
	20	168·00	15·35	270·0	40·0
	50	127·09	13·21	245·0	24·0

pronounced, especially with H-acid and 1, 2, 4-acid. Present investigation supports the studies of Datta *et al* (1977), Nanda and Kumar (1977), Datta *et al* (1978), Tayal and Sharma (1980) and Malik *et al* (1986) with different crop species. Similarly, through exogenous application of some phenols, Singh *et al* (1980) obtained increased economic yields of chickpea. Enhancement of yield parameters in mungbean (Chander 1982), peanut (Parmar *et al* 1982; Malik *et al* 1986), pigeon pea (Singh *et al* 1986) and rice (Parmar *et al* 1986) have been recorded.

A better nutritional quality of chickpea seed would depend upon the presence of high soluble protein, free amino acids and soluble sugar contents. On the contrary, high starch and low protein seeds are not nutritionally desirable. Among the treatments tried, H-acid (5 and 20 ppm), resorcinol (50 ppm) and RD-brown (5 ppm) produced better quality seeds. Amongst the yield contributing parameters, H-acid (20 and 50 ppm), RD-brown (50 ppm) and 1, 2, 4-acid (50 ppm) caused the best performance. The treatments which caused both qualitative and quantitative increments were H-acid (20 and 50 ppm), resorcinol (50 ppm) and RD-brown (5 ppm).

Total free amino acids and soluble sugar contents of mature seeds were enhanced by all the treatments, though RD-brown (50 ppm) caused retrogression of total soluble sugar content of the mature seeds. The treatments caused varied effects on the starch content of seeds compared with the control. All the concentrations of 1, 2, 4-acid, H-acid, except (20 ppm) and resorcinol (except 5 ppm) decreased starch content of the seeds, while all concentrations of RD-brown promoted its level. Monophenolics cause the activation of IAA-oxidase activity thereby lowering the auxin level (Henderson and Nistch 1962), and altering the source-sink relation. Wynn and Fore (1965) and Emmanual (1968) described phenols as the most effective inhibitors of oxidative phosphorylation. Phenols promote the biosynthesis of nucleic acids and proteins (Kefeli and Kutacek 1977), also increase the activities of amylases, IAA-oxidase, peroxidase and polyphenol oxidase (Kumar and Nanda 1981). Phenolics are also reported to increase seed protein content in mungbean (Kalita and Shah 1983) and oil in peanut (Malik *et al* 1986).

Among the phenolic acids, 1, 2, 4-acid and H-acid are monophenols, whereas resorcinol and 4, 6-bis (diazonaphthalene sulphonate)-resorcinol are diphenols. Both the monophenols significantly increased number of pods/plant and yield (kg/ha) over the control. The physiological role of phenolic substance is controversial. Some workers cast doubt on their role in the regulation of plant growth since they are confined to plant vacuoles. Kefeli and Dashek (1984) have inferred that endogenous phenols are stimulatory and promote growth. These workers have suggested that caffeic acid and ferulic acid have auxin-like characteristics. The general view is that monophenols act as cofactors of IAA oxidase, whereas polyphenols inhibit the activity of IAA oxidase leading to the synergism of IAA action (Tomazewski and Thimann 1966). Hess (1968) suggested that the occurrence of two-OH groups at the *ortho*-position with a free *para*-position was an essential requirement for a phenolic compound to be biologically active. Pilet (1966) and Akburg and Johanson (1969) noticed that di- and polyphenols were promotive. A lack of structural relationship of phenols with their activity is reported recently (see Malik *et al* 1986). The present studies clearly show that phenolics could be effectively used in increasing yield of pulses.

Phenolic acids, thus, make available high levels of soluble sugars by suppressing oxidative phosphorylation which is detoured towards biosynthesis of free amino acids and protein. Our studies also show that increased free amino acids content is not due to enhanced protein degradation but rather due to their increased production and interconversion. This may be the cause for high levels of soluble proteins, free amino acids and soluble sugars recorded in the present investigation.

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