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Effect of Phenolic Compounds on Growth, Yield and Quality of Indian Mustard (*Brassica juncea*)

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Foliar spraying of *Brassica juncea* with phenolic compounds, namely RD brown and resorcinol (200 μg ml^{-1} each); modified the canopy structure of plants by increasing primary, secondary and tertiary branching. The seed yield per plant also increased greatly mainly due to significant increase in number of inflorescences and siliquae per plant, 100 seed weight and number of seeds per siliqua with these treatments. The percentage of underdeveloped siliquae and shattering of siliquae also declined. These compounds increased total dry matter of plants, partitioning coefficient and harvest index. Analyses of harvested seeds showed significant enhancement in the levels of starch and total soluble sugars with RD brown and resorcinol. The contents of proteins and glucosinolates decreased while that of oil remained unchanged with these compounds.

Key Words: Phenolic compounds; RD brown, Resorcinol, Indian mustard; *Brassica juncea*, Growth, Yield

Introduction

In oleiferous *Brassica* spp. the indeterminate growth, non-synchronous fruit maturity, shattering of fruits and lodging of plants are major constraints for low yields. Existence of competition for nutrients among simultaneously growing stem, developing fruits and newly formed flowers, and insufficient availability of assimilates to the developing embryos also lead to reductions in quantity and quality of seeds, particularly in late formed flowers (Austin 1986, Clarke 1979). Chemical plant growth regulators are being increasingly used as an aid to enhance yield in crop plants and several of these compounds have been shown to modify canopy structure and other yield attributes in *Brassica* spp. (Rademacher 1990, Setia & Setia 1990). Of late, numerous phenolic compounds have been shown to stimulate growth (Kefeli & Dashek 1984, Malik et al. 1986b), and recently salicylic acid, a monophenol, has been found to function as 'calorigen' during inflorescence development in *Arum* lilies (Raskin et al. 1987, 1989) and as natural endogenous transduction signal involved in protein synthesis in tobacco to induce resistance against tobacco mosaic virus (Malamy et al. 1990). Some studies on leguminous crops have shown growth promoting effects of commercially available phenolic compounds such as 1,2,4-acid, H-acid, RD brown, resorcinol, R-salt and G-salt (Malik et al. 1986b, Setia N et al. 1989). These compounds modify the growth, morphological and yield contributing characteristics of plants that lead to better yield and quality of seeds. The present investigation was designed to evaluate the effects of two phenolics, RD brown and resorcinol, on growth, yield and yield components in Indian mustard (*Brassica juncea* cv. RLM 514).

Material and Methods

Seeds of Indian mustard, *Brassica juncea* (L.) Czern & Coss, cv. RLM 514, were procured from the Department of Plant Breeding, Punjab Agricultural University, Ludhiana, and experiments were conducted in the field area of the Department of Botany during 1986/87. Plants were raised in a randomized block design using three replicates of 3m long, 10 row plots with a 45 cm interrow spacing and 20 cm between the plants within each row. The experimental plots received a basal applicaton of N and P at the rate of 100 kg urea and 30 kg superphosphate ha^{-1}. At anthesis the plants were sprayed with aqueous solutions of RD brown (4,6-bis-diazonaphthalene sulphonate) or resorcinol (1,3-dihydroxy benzene) each at 200 $\mu g\ ml^{-1}$ containing 0.5% (v/v) Triton X-100. Two more sprays of these phenolics were given at weekly intervals. Plants sprayed with water containing Triton X-100 served as control. To control mustard aphid the plants were sprayed with Metasystox 25 EC at flowering and early siliqua formation stage. The plants were harvested at maturity attained in about 170 days after sowing. Data on plant height (cm), number of primary, secondary and tertiary branches, siliqua number (mature, immature and shattered), siliqua length (cm), seed number per siliqua, seed yield (g) per plant, 100 seed weight and plant dry matter (g) were recorded on 10 random plants from central rows of each plot. Harvest index and partitioning coefficients were calculated as per cent ratio of seed yield and siliqua weights to plant dry matter, respectively. The data on dry matter of stem, leaves and fruits were also recorded at monthly intervals starting from 50 DAS (days after sowing) until maturity from five plants to calculate partitioning of dry matter as a ratio of stem weight or leaf weight or fruits weight to plant dry matter. Harvested seeds from control and treated plants were analysed for total soluble sugars (Clegg 1956), starch (McCready et al. 1970) and proteins (Lowry et al. 1951). Oil in seeds was determined by method of Kartha and Sethi (1957) and verified by Newpont Analyser, wideline NMR (Model MK IIIA). Glucosinolates were estimated by colorimetric method of Brzezinski and Mendolewski (1984).

Results

Data on the effects of RD brown and resorcinol on growth and yield parameters of *Brassica juncea* are shown in table 1. Both the treatments enhanced plant height significantly. The treated plants were more erect, stouter and exhibited better tensile strength (tested manually) than controls. The primary effects of RD brown and resorcinol were enhancement of branching and inflorescences with a consequent increase in yield. Increases in number of primary, secondary and tertiary branches with RD brown were highly significant. Resorcinol, however, caused maximum increase (about 47%) in number of tertiary branches. As a result, the number of inflorescences increased by 54 and 47% with RD brown and resorcinol treatments, respectively.

The total number of siliquae per plant enhanced significantly by about 100 and 63% with RD brown and resorcinol, respectively (table 1). The percentage of mature siliquae showed increases by 12 to 14% over control due to these treatments. Consequently, the percentage of immature siliquae decreased in treated plants. The shattering of siliquae also declined by 5 and 8% with RD brown and resorcinol, respectively (table 1). Seed yield per plant showed significant increase of about 119% over controls following these treatments. One hundred seed weight also enhanced by 18 and 26% with RD brown and resorcinol, respectively (table 1).

There were also considerable improvements in harvest index (HI) and partitioning coefficient due to RD brown and resorcinol treatments (table 1), which indicated enhanced dry matter accumulation in reproductive structures. Data on accumulation and partitioning of dry matter in different plant parts in *Brassica* are shown in figures 1-3. The accumulation of dry matter was low until 110 DAS (when most of the leaves had abscinded) but showed a steep rise thereafter (figure 1A). With RD brown and resorcinol the total dry matter (TDM) of the plants at final

Table 1 *Effect of RD brown and resorcinol (200 μg/ml each) on growth and yield attributes of Indian mustard (Brassica juncea cv. RLM 514). Data were recorded from 170 days old plants at harvest*

Characters	Control	Treated	
		RD brown	Resorcinol
Plant height (cm)	175.8 ±21.11	197.4* ±11.82	200.0* ±15.13
No. of branches			
Primary	4.63 ± 1.007	7.12* ± 2.15	5.5 ± 1.18
Secondary	9.13 ± 5.56	16.75* ± 7.41	14.38 ± 4.52
Tertiary	19.38 ± 8.18	26.75* ± 8.72	28.50* ±14.54
No. of inflorescences	29.38 ± 9.40	45.25* ±14.39	43.25* ±13.19
No. of siliquae			
Total	365.50	733.75*	593.13*
Mature	200.00	491.38*	405.75*
Immature	60.50	70.13	66.88
Shattered	105.00	172.25	120.50
Siliqua Length (cm)	4.64 ± 1.80	4.74 ± 0.07	4.72 ± 0.23
No. of seeds/siliqua	11.47 ± 1.5	13.41 ± 1.12	13.80 ± 1.19
Seed yield/plant (g)	8.98 ± 5.31	19.54* ± 7.06	19.47* ± 5.12
100 seed weight (g)	0.306± 0.04	0.362*± 0.06	0.386*± 0.04
Harvest Index (HI)	0.128± 0.09	0.161 ± 0.07	0.194 ± 0.04
Partitioning coefficient	22.1	29.5	34.5

* Significant at 5% level

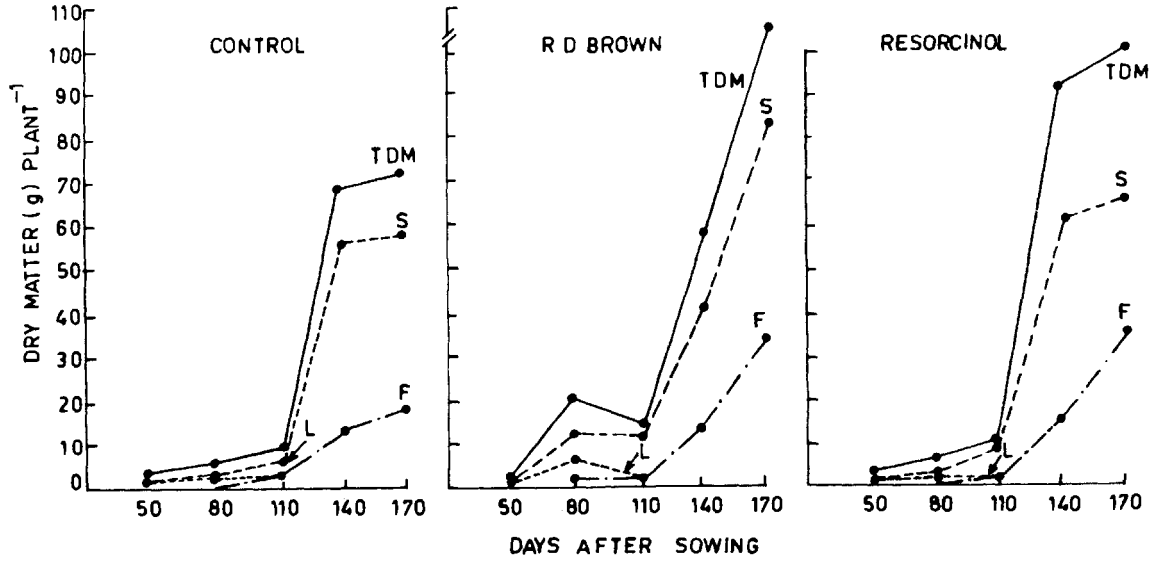

Figure 1 Effect of RD brown and resorcinol on dry matter accumulation in total plant (TDM), leaf (L), stem (S) and fruit (F) during growth of *Brassica juncea*

harvest was enhanced by 73 and 31%, and stem dry matter by 55 and 20%, respectively, over their coresponding controls (figure 1B,C). Increases in siliquae dry matter were to the extent of 130% with both the treatments. Figures 2A-C shows that percentage accumulation of dry matter was also altered by RD brown and resorcinol at different stages of plant development. From 110 DAS onwards the percentage accumulation of dry matter was low in stem but high in siliquae with both the treatments in contrast to controls. Dry matter partitioning ratios in different plants organs also indicate enhanced partitioning of dry matter towards siliquae due to RD brown and resorcinol treatments (figure 3).

Analyses of harvested seeds from treated plants indicated some change in their biochemical composition (table 2). There was no appreciable increase in total oil content but the level of proteins declined with both the treatments. The levels of starch and total soluble sugars showed significant increases over controls with RD brown and resorcinol. The glucosinolate content in the seed meal declined by about 34% with resorcinol (table 2).

Discussion

In this study both RD brown and resorcinol improved yield in *Brassica juncea* by enhancing the number of branches, number of siliquae per plant, 100 seed weight and number of seeds per siliqua. These phenolic compounds appear to have affected metabolic and cell divisional activities in shoot apical meristem which led to increased branching and development of more inflorescences with consequent enhancement in number of siliquae per plant. The increase in percentage of mature fruits in treated plants might be due to increased availability and diversion of nutrients toward developing fruits. Both the tested phenols also enhanced dry matter production and led to higher partitioning coefficient and harvest index in *Brassica*. Though underlying mechanism regulating the partitioning of assimilates between vegetative and reproductive structures is poorly understood (Gifford & Evans 1981) these phenolic compounds appear to influence these processes positively in *Brassica juncea* resulting in increased yield. Yield enhancement with various phenolic compounds has also been reported in triticale (Datta & Nanda 1978), gram (Tayal & Sharma 1982), groundnut (Malik et al. 1986a) and lentil (Setia N et al. 1989).

Considerable seed loss takes place in *Brassica* before or during harvest due to shattering of fruits which is correlated with hormonal imbalances (Picart & Morgan 1984) and poorly developed lignified cells in fruit wall (Kadkol et al. 1986, Setia et al. 1989b). Slight reductions in shattering of siliquae in RD brown and resorcinol-treated plants might be due to increased lignification in siliqua valves in the vicinity of main vascular bundles as also reported with other phenols (Setia et al. 1989b).

RD brown and resorcinol also modified the concentrations of various seed reserves. There was increase in levels of starch and soluble sugars and decrease in protein content. The levels of glucosinolates was markedly reduced with resorcinol treatment and only slightly with RD brown. The presence of glucosinolates in the seed meal left after oil extraction reduces its quality for use as cattle feed as glucosinolates yield toxic and goitrogenic cleavage products which produce pungent taste and lower the palatability of feed (Bell 1977).

Table 2 *Effect of RD brown and resorcinol on oil (%), protein starch, soluble sugars (mg/g dry wt) and glucosinolates (μ moles/g defatted seed meal) contents of seeds of Indian mustard (**Brassica juncea** cv. RLM 514)*

Chemical constituents	Control	Treated	
		RD brown	Resorcinol
Oil	40.2	40.8	40.7
Protein	193.2	184.8	147.0
Starch	36.0	70.2*	68.0*
Total soluble sugars	14.0	20.0*	24.0*
Glucosinolates	98.0	96.0	64.0*

* Significant at 5% level

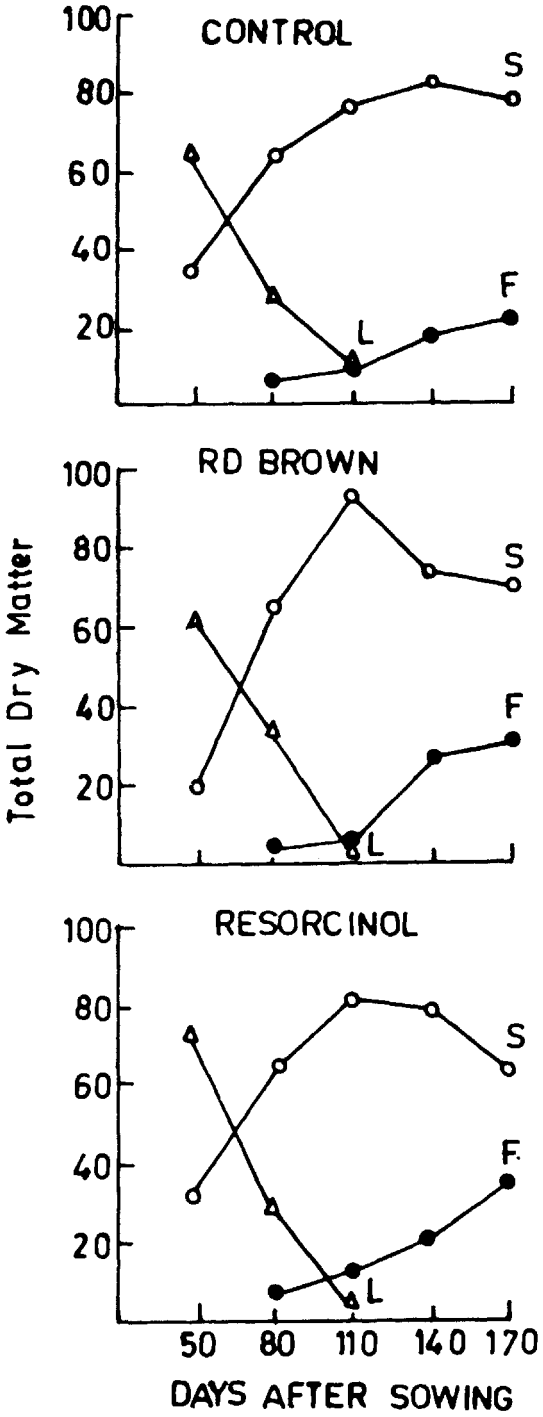

Figure 2 Effect of RD brown and resorcinol on per cent dry matter accumulation in stem (S), leaf (L) and fruit (F) during growth of *Brassica juncea*

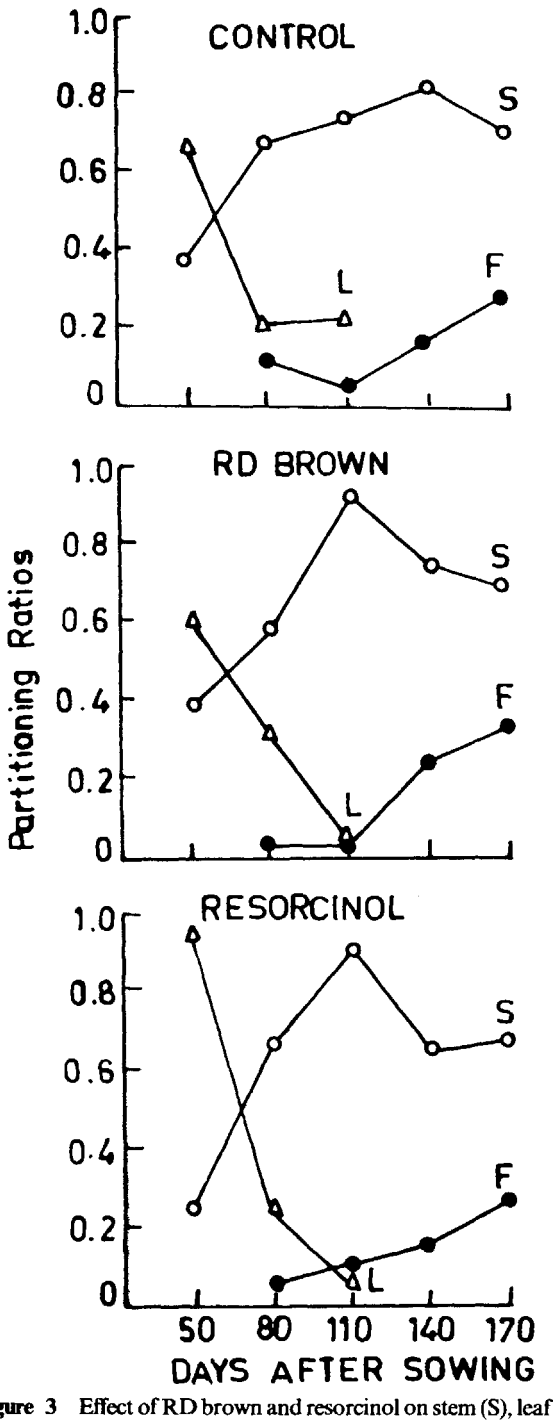

Figure 3 Effect of RD brown and resorcinol on stem (S), leaf (L) and fruit (F) dry matter to total plant dry matter partitioning ratio at different growth stages of *Brassica juncea*

The improvement in the biochemical constituents of *Brassica* seed by these tested phenols might be the result of increased availability of nutrients towards developing fruits. The role of plant growth regulators and different phenolic compounds in improving nutrient quality of seeds is well established (Eeuwens & Schwabe 1975, Malik et al. 1986b, Setia et al. 1989, Shroeder 1984). Further, phenols are also known to modify the endogenous levels of phytohormones (Kefeli & Dashek 1984) which thereby influence various plant processes leading to improved yield and quality of seeds.

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