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Influence of Sodium Nitroprusside (Nitric Oxide Releaser) on Yield Components and Seed Quality of *Brassica napus* L.

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Abstract

Foliar applications of sodium nitroprusside (SNP), a nitric oxide releasing compound, on field grown oilseed rape (Brassica napus cv GSL-1) plants resulted in enhancement of yield and improvement of seed quality. SNP treatments (50, 100, 200 and 400 µg/ml) increased plant height and number of primary and secondary branches. The number of siliquae per plant, number of seeds per siliqua and 1,000-seed weight also increased significantly with consequent enhancement in seed yield per plant following SNP treatments. The partitioning coefficient also showed increase but there was no appreciable change in harvest index. Analyses of mature seeds from SNP treated plants exhibited higher accumulation of various biochemical reserves, such as total soluble sugars starch, total soluble proteins and total free amino acids. The seed oil content also increased by about 2 percentage points following 100 µg/ml SNP treatment. The seeds from SNP treated plants exhibited better germinability, more water imbibition capacity and decreased electrolyte leakage.

Key words : *Brassica napus,* Sodium nitroprusside, Nitric oxide, Seed quality, Germination.

Plant growth regulators (PGRs) are being increasingly used as an aid to yield enhancement in crop plants. Different oleiferous *Brassica* spp. are reported to respond advantageously to various PGRs in improving seed yield and seed quality (1). Nitric oxide (NO) is a bioactive molecule and an upcoming non-conventional regulator of diverse physiological processes in plants (2). NO has been reported to be involved in various aspects of plant growth and development including photomorphogenesis, leaf expansion, seed germination, senescence, abiotic and biotic stresses and signal transduction (3—5). Exogenously applied NO releasing compound, like sodium nitroprusside, have been reported to influence most of these processes in plants (6). Thus, keeping in view of the emerging role of NO in mediating several plant processes and amenability of *Brassica* spp. to morpho-physiological and biochemical modifications in response to PGR applications, the present investigation was designed to study the influence of exogenously applied nitric oxide (using sodium nitroprusside—SNP, as its source) on yield components and seed quality in oilseed rape, *Brassica napus.*

Methods

The seeds of *Brassica napus* (cv GSL-1) were procured from the Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana and plants were raised in small plots according to the recommended practices for fertilizer application, plant protection and irrigation to optimize seed yield under field conditions. At rosette stage (61 days after sowing-DAS) the plants were foliarly sprayed with SNP solutions (50, 100, 200 and 400 µg/ml) containing 0.01% triton-X as surfactant. The SNP treatments were repeated twice after an interval of one week each. Thereafter, one more foliar application of SNP was given to plants at early flowering stage (84 DAS). The plants sprayed with water containing triton-X served as control. Three replicates were maintained for each treatment. The plants were harvested at maturity (156 DAS). The data on various yield components were recorded from five plants removed randomly from central rows of each plot. Harvest index (HI) was calculated as the ratio of seed yield to the total above ground dry matter, and the partitioning coefficient (PC) as the per cent ratio of siliqua weight

Table 1. Influence of sodium nitroprusside (SNP 50, 100, and 400 μ g/ml) on yield components in *Brassica napus* (cv GSL 1) at final harvest. ± Standard error. *Significant at 5% level of significance. NS, Non-significant.

Character	Control	Treatments SNP (μ g/ml) 50	100	200	400	CD at 5% level of significant
Plant height	168 ± 2.51	176 ± 2.62*	179 ± 2.05*	183 ± 1.00*	171 ± 2.31	4.15
No. of branches						
Total	31.66 ± 2.82	36.34 ± 2.96*	39.34 ± 5.41	42.00 ± 7.07*	37.00 ± 2.96*	4.15
Primary	8.33 ± 0.16	10.67 ± 2.08*	11.67 ± 1.16*	12.33 ± 0.58*	10.33 ± 1.0*	1.52
Secondary	23.33 ± 1.53	25.67 ± 1.57*	27.67 ± 1.53*	29.67 ± 2.52*	26.67 ± 1.46*	3.04
No. of siliquae/plant	491.58 ± 3.98	543.57 ± 5.06*	570.23 ± 9.01*	580.86 ± 12.40*	553.02 ± 7.86*	48.11
No. of seeds/siliqua	18.00 ± 1.98	20.00 ± 2.56*	21.00 ± 2.26*	24.00 ± 1.82*	19.00 ± 2.96	1.22
1000-seed weight	3.10 ± 0.91	3.58 ± 0.78*	3.65 ± 0.96*	3.68 ± 0.82*	3.53 ± 0.78*	0.11
Seed yield/plant	26.93 ± 1.98	33.89 ± 2.17*	35.28 ± 2.70*	36.09 ± 2.91*	33.12 ± 2.40*	4.75
Harvest index	0.38 ± 0.03	0.44 ± 0.04*	0.39 ± 0.04*	0.38 ± 10.04	0.45 ± 0.03*	0.03
Partitioning coefficient	56.38 ± 3.61	60.53 ± 3.29	65.00 ± 3.55	67.05 ± 4.09	58.00 ± 2.46	NS

to the total above ground dry mater. The seeds harvested from control and SNP treated plants at maturity were analyzed for total soluble sugars (7), starch (8), total soluble proteins (9), total free amino acids (10) and oil content (11). These seeds were also subjected to germination and membrane permeability studies. For germination studies the seeds were surface-sterilized by soaking in an aqueous solution of $HgCl_2$ (0.1%) for 1 min followed by several rinses with distilled water. Twenty seeds each were placed in petridishes lined with two layers of filter paper moistened with distilled water. Three replicates were kept for each treatment. Germination was carried out at 25 C in BOD incubator. Germination percentage was recorded on day 5 as per cent ratio of number of seeds germination to total number of seeds.

The membrane permeability of the seed coat was measured in terms of imbibition rate and per cent electrolyte leakage from seeds. A known weight of seeds from control and SNP treated plants were soaked in 5 ml solution of distilled water in test tubes. After 6 h, the seeds were taken out from test tubes and surface water was blotted off without putting any pressure. Seeds were then immediately weighed to obtain their saturated weight.

$$\text{Imbibition rate} : \{[\text{Saturated weight} - \text{Initial rate}]/\text{Initial weight})\} \times 100$$

The per cent electrolyte leakage was calculated using conductivity meter referred as electrical conductivity (EC) (12).

$$\text{Per cent EC} = (B/A) \times 100$$

A = EC of leachate before crushing seeds,
B = EC of leachate after crushing seeds

Results and Discussion

Table 1 shows that different SNP treatments caused small increase in plant height but significant enhancement in the number of primary and secondary branches. Following 50, 100, 200 and 400 μg/ml SNP treatments the per cent increase in total number of branches per plant was about 15, 24, 33 and 17, respectively, over controls. Concomitant with the increased branching, the number of siliquae per plant also increased significantly with a maximum increase of about 18% recorded in 200 μg/ml SNP treated plants. The number of seeds per siliquae and 1,000-seed weight also showed increases following SNP treatments. The maximum increase in these parameters was recorded in 200 μg/ml SNP treated plants which was about 24% for number of seed per siliqua and 19% for 1,000-seed weight, respectively. Consequently, the seed yield per plant also showed increase by about 26, 31, 34 and 23% due to 50, 100, 200 and 400 μg/ml SNP treatments, respectively, over control. SNP did not cause any appreciable change in harvest index but improved partitioning coefficient considerably.

In *Brassica* species the yield is dependent upon number of branches, number of siliquae per plant, number of seeds per siliqua and 1,000-seed weight (13). SNP enhanced the seed yield by influencing the

Table 2. Influence of sodium nitroprusside (SNP 50, 100, 200 and 400 µg/ml) on the level of various reserves (mg/g FW) and per cent oil content in seed at maturity in *Brassica napus* (cv/GSL 1). ± Standard error. +Significant at 5% level of significance.

Treatments SNP (µg/ml)	Total soluble sugars	Starch	Total soluble proteins	Total free amino acids	Per cent oil
Control	16.43	23.95	15.85	0.03	40.13
50 SNP	17.39	26.47	17.20	0.05	41.06
100 SNP	18.45	27.83	19.30	0.06	42.40
200 SNP	17.78	30.29	21.80	0.08	41.73
400 SNP	18.15	24.79	18.30	0.07	41.60

mentioned characters, especially the number of siliquae per plant. This chemical seems to have influenced metabolic and cell divisional activities in shoot apical meristem which lead to increased branching and with consequent enhancement in number of siliquae per plant and thus seed yield. It has been demonstrated that higher yields of different crop species can result from changes in the partitioning of assimilates towards sinks (14, 15). Improved PC favors this contention.

Table 2 shows that seeds harvested from SNP treated plants exhibited greater amount of total soluble sugars, starch, total soluble proteins and total free amino acids as compared to controls. SNP at 100 µg/ml concentration caused maximum increase in the level of total soluble sugars and starch, whereas 200 µg/ml SNP treatment increased the content of total soluble proteins and total free amino acids to a maximum extent. The total seed oil content also showed increase. A maximum increase in seed oil content recorded was by 2.27 percentage points in 100 µg/ml SNP treated plants over controls (Table 1). The increase in the levels of various seed reserves, including oil, due to SNP treatments might be the result of increased availability of assimilate towards developing fruits/seeds. The role of PGRs in improving nutrient of seed is well established (16, 17).

Table 3 depicts that seeds from SNP treated plants showed higher germination percentage than controls. The germination percentage of seeds from control plants was 83, while that in seeds from 50, 100, 200 and 400 µg/ml SNP treated plants it was 97, 93, 90 an 93, respectively. The seeds from SNP treated plants also exhibited higher imbibition rate which was maximum in seeds from 100 µg/ml SNP treated plants. SNP treatments also modified membranes properties as indicated by decreased percent electrolyte leakage from the seeds as compared to controls (Table 3). The electrolyte leakage recorded from seeds of 50, 100, 200 and 400 µg/ml SNP treated plants was 20, 17, 18 and 22%, respectively, as compared to 25% from control. Exogenous application of nitric oxide and related nitrogen oxides have been reported as stimulator of seed germination and break dormancy (18, 19). SNP treatments reduced the per cent electrolyte leakage from seeds indicating thereby possibility of its role in improving or maintenance of membrane integrity. Similar observations were reported by Maskri et al. (20) and Afzal et al. (21).

Table 3. Influence of sodium nitroprusside (SNP 50, 100, 200 and 400µg/ml) on the germination percentage (day 5), imbibition rate and per cent electrolyte leakage of seeds at maturity in *Brassica napus* (cv GSL 1).

Treatments SNP (µg/ml)	Per cent germination	Imbibition rate	Per cent electrolyte leakage
Control	83.33	49.00	25.00
50	96.67	51.00	20.00
100	93.67	61.00	17.00
200	90.00	55.00	18.00
400	93.33	53.00	22.00

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