Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(4): 2934-2938
Received: 01-05-2019
Accepted: 03-06-2019

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Effect of bio-fertilizers in combination with chemical fertilizers on flowering, yield and quality of mango (*Mangifera indica* L.) cv. Amrapali

Nehete DS and Jadav RG

Abstract
A field experiment was conducted to find out most appropriate combination of bio-fertilizers and chemical fertilizers for mango production during 2011 - 13 at the Horticultural Research Farm, Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand. The trial was laid out in randomized block design, replicated thrice, with thirteen treatments including control. Maximum number of panicles per branch (9.38), minimum days taken to 50% flowering (21.38), panicle length (43.38 cm), number of flowers per panicle (1779.38) and minimum sex ratio of flowers (0.73), highest fruit set per panicle (201.33), fruit retention per panicle (4.70), fruit length (11.84 cm), fruit diameter (6.49 cm), fruit weight (179.21 g), number of fruits per tree (556.00), fruit yield per tree (54.00 kg) and per hectare (84.24 q) and pulp weight (114.75 g) were found significant under T10 i.e. 85% N + 85% P2O5 + Azotobacter + PSB. Stone weight (28.41 g) was found minimum under the treatment T6 (100% N + 85% P2O5 + Azotobacter + PSB). Peel weight (28.00 g) was recorded significantly minimum in treatment T13 i.e. 70% N + 85% P2O5 + Azotobacter + PSB, while early emergence of flowering i.e. 181.13 days taken during on pooled basis was observed non significant.
The maximum TSS (21.43%), total sugar percentage (18.82%), reducing sugars (8.80%) and ascorbic acid (42.76 mg/100 g of pulp) were significantly increased in T13 (70% N + 85% P2O5 + Azotobacter + PSB) in pooled results. While, non-reducing sugar i.e. 10.30% in 100% N + 85% P2O5 + Azotobacter + PSB (T6) and minimum acidity (0.129%) was significantly recorded in treatment T10 (85% N + 85% P2O5 + Azotobacter + PSB).

Keywords: Mango, flowering, yield, quality and Amrapali

Introduction
Mango (*Mangifera indica* L.) belongs to the family Anacardiaceae. It is grown almost in 63 countries of the world. This fruit crop occupies a unique place amongst the fruit crops grown in India. In Western India, several mango varieties *viz.*, Alphonso, Kesar, Rajapuri, Pairi, Dashehari, Langra, Neelum, Amrapali and Mallika are commercially grown and accepted by the consumers. Amrapali is a hybrid developed at IARI, New Delhi through crosses between Dashehari × Neelum. It is precocious dwarf (suitable for high density planting), regular bearer and good cropper. Fruits are green, apricot yellow, medium sized sweet in taste with high T.S.S. and pulp content (75%), while flesh is fibreless and deep orange red. Application of manures and fertilizers through soil is not enough to produce qualitative mango fruits. Decline in soil health due to excessive dependence on chemical inputs left us with no other option but to utilising biological inputs like biofertilizers which is sought to be one of the answers to restore the soil health apart from solving nutrition problem of plants. Biofertilizers are microbial preparations containing living cells of different microorganisms which have the ability to mobilize plant nutrients in soil from unusable to usable form through biological process. They are environmental friendly and play significant role in crop production. It is mainly used for field crops but now-a-days it is used for fruit crops also. Biofertilizers are able to fix 20–200 kg N/ha/year, solubilize P in the range of 30–50 kg P_2O_5 ha/year and mobilizes P, Zn, Fe, Mo to varying extent. Biofertilizers are used in live formulation of beneficial microorganism which on application to seed, root or soil, mobilize the availability of nutrients particularly by their biological activity and help to build up the lost micro flora and in turn improved the soil health in general (Hazarika and Ansari, 2007) [5]. Considering the importance and future scope of mango fruit, it was decided to conduct the present experiment with the objectives to find out the effect of bio-fertilizers in combination with chemical fertilizers on growth of mango cv. Amrapali.

Materials and Methods

A field experiment was conducted at the Horticultural Research Farm, Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand during *Rabi – Summer* season of the year 2011 - 12 and 2012 - 13**.** The soil samples of location before conducting experiment in main field were analyzed for essential nutrients, organic carbon, EC and pH (Jackson, 1973) [6]. The details of value is given in Table 1, which shows the soils to be medium in available nitrogen and available phosphorous was low, whereas available potash is high at location of experiment, while organic carbon was low at the location. The experiment consisted of thirteen treatment combinations, comprised of three nitrogen levels (100, 85 and 70% of RDF), two levels of phosphorous (100 and 85% of RDF) and bio-fertilizers (*Azotobacter*, PSB each of 5 ml/ tree). The details of treatments are given in Table 2. According to treatment, 50% N and 100% P2O5 of each treatment were applied at the time of onset of monsoon by (18th July and 12th July during 2011-12 and 2012-13, respectively) making ring with 15 cm deep and 1.5 m away from main trunk Second dose of 50% N was applied at flowering stage (21st February and 12th February during 2011-12 and 2012-13, respectively). According to treatment, 5ml of each of *Azotobacter* and PSB were dissolved in 1 litre water and mixed with 80 kg FYM (well decomposed organic manure). This mixture was applied at the time of onset of monsoon(1st August and 23rd July during 2011-12 and 2012-13, respectively). At the time of flowering stage 5ml of each of *Azotobacter* and PSB were dissolved in 1 litre water and mixed with 20 kg finely powdered FYM. This mixture was given on 3rd March and 23rd February during 2011-12 and 2012-13, respectively.

Potassium 100%, FYM @ 100 kg/tree were applied as a common dose to ten year old experimental trees. The experiment was laid out in a Randomized Block Design with four replications. The soil of the experimental site was sandy loam, locally known as "*Goradu*". Data obtained from study for two consecutive years were pooled and statistically analyzed as procedure given by Panse and Sukhatme (1967) [9].

Result and Discussion

Data presented in Table 1 influence of biofertilizers in combination with chemical fertilizers emergence of flowering was observed non-significant results. Significantly the maximum number of panicles per branch (9.38) was recorded with 85% N + 85% P_2O_5 + *Azotobacter* + PSB (T_{10}) and remained at par with T_{13} and T_8. While, significantly minimum days taken to 50% flowering (21.38) was reported in 85% N + 85% P_2O_5 + *Azotobacter* + PSB (T_{10}). Similarly, significantly maximum panicle length (43.38 cm) was also obtained under 85% N + 85% P_2O_5 + *Azotobacter* + PSB (T_{10}) which remained at par with T_{11} and T_8.

Significantly the maximum number of flowers per panicle (1779.38) was observed in treatment T_{10} (85% N + 85% P_2O_5 + *Azotobacter* + PSB) and remained at par with T_8, T_{13}, T_{12} and T_6. Likewise, significantly the minimum sex ratio (0.73) of flowers was also recorded in treatment 85% N + 85% P_2O_5 + *Azotobacter* + PSB (T_{10}) and it remained at par with T_8, T_{13} and T_{12}.

These might be due to facts that in conditions of adequate nutrition provided through NPK, FYM and biofertilizers, the trees remained more vegetative and hence, accumulation of carbohydrates induce early flowering. It also helpful in maintaining a particular C: N ratio (CCC: NN) in shoots which is essential to produce flowers (Kunte *et al.,* 2005). The increased in flowers may be due to increased in nutrients availability from FYM, the organic phosphorous through phosphobacteria and IAA from *Azotobacter* which may have increased various endogenous hormonal levels in plant tissue might be responsible for enhancing flowering.

These results are also in conformity of those obtained by Yadav *et al.,* (2011) [15] in mango, Dheware and Waghmare (2009) [3] in sweet orange and Shukla *et al*. (2009) [13], Barne (2011) [1] and Godage (2012) [4] in guava.

The highest fruit set per panicle (201.33) was observed in treatment T_{10} *i.e.* 85% N + 85% P_2O_5 + *Azotobacter* + PSB and remained at par with T_8 followed by T_{13} and T_{12}. Significantly the highest fruit retention per panicle (4.70) was reported in T_{10} *i.e.* 85% N + 85% P_2O_5 + *Azotobacter* + PSB which was at par with T_8 followed by T_{12} and T_{13}.

The increased in fruit set may be due to increased in availability of nitrogen to the plant as well as its translocation from root to flower. Simultaneously synthesis of bioregulator shifted the endogenous balance between promoters and inhibitors in favour of fruit forming processes. The increased in fruit set is due to cumulative effect of biofertilizers, organic manures and inorganic fertilizers (Mahendra and Singh, 2009b). Maximum fruit retention per panicle might be due to supply of all the nutrients in adequate right from starting of the experiment to the harvesting of the crop, which induced more flowering and retention of fruits by supply of photosynthates at critical requirement stage (Mahendra and Singh, 2009b).

The results were also in accordance with the findings of Yadav *et al.* (2011) [15] in mango, Yadav *et al.,* (2009) in aonla, Mahendra and Singh (2009b) in ber, Barne (2011) [1] and Godage (2012) [4] in guava, Dheware and Waghmare (2009) [3] in sweet orange and Baviskar (2011) [2] in sapota.

The physical parameters of fruits like maximum fruit length (11.84 cm) and fruit diameter (6.49 cm) were obtained under 85% N + 85% P_2O_5 + *Azotobacter* + PSB (T_{10}) which was at par with T_8, T_{13}, T_{12} and T_6. The treatment T_{10} *i.e.* 85% N + 85% P_2O_5 + *Azotobacter* + PSB recorded significantly the maximum fruit weight as compared to rest of the treatments. While, treatment T_{13} *i.e.* 70% N + 85% P_2O_5 + *Azotobacter* + PSB recorded minimum peel weight and which was found at par with treatment T_{12} followed by T_4, T_{10} and T_8 (Table 4). Significantly maximum pulp weight by treatment T_{10} (85% N + 85% P_2O_5 + *Azotobacter* + PSB) as compared to rest of treatments. While, minimum stone weight (28.41 g) was observed under treatment 100% N + 85% P_2O_5 + *Azotobacter* + PSB (T_6) and remained at par with T_1, T_4, T_7, T_8, T_{12} and T_{13}.

The fruit characters *viz.,* fruit length, fruit diameter, fruit weight, pulp weight, peel weight and stone weight were improved by the application of NPK along with FYM and bio-fertilizers. These might be due to accumulation of more food material in the trees by an efficient utilization for development of fruits. The marked effect of nitrogen on various characters of fruits was due to increased in the efficiency of metabolic processes and thus encouraged the growth of the plant in general and consequently the various parts of the plant including fruit. The application of N, P and K fertilizers might have resulted in high rate of photosynthesis results leads to higher carbohydrate accumulation in fruit and thereby increasing in fruit size and weight. They also enhanced the plant growth through their beneficial effects, which in turn resulted in higher fruit size (Singh *et al*. 2003) [14].

These observations are in agreement with findings of Patil *et al.*, (2005) [11] and Yadav *et al.*, (2011) [15] in mango, Mahendra and Singh (2009a) [7] in ber, Pilania *et al.*, (2010) [12], Barne (2011) [1] and Godage (2012) [4] in guava, Patel and Naik (2010) and Baviskar (2011) [2] in sapota and Dheware and Waghmare (2009) [3] in sweet orange.

Significantly the maximum number of fruits per tree (556.00 on pooled basis) was recorded by T_{10} (85% N + 85% P_2O_5 + *Azotobacter* + PSB) as compared to rest of treatments, except T_8. Similarly, significantly the higher yield (54.00 kg/tree and 84.24 q/ha) was noticed in 85% N + 85% P_2O_5 + *Azotobacter* + PSB (T_{10}) which was at par with T_8 and T_{13}.

The increased in number of fruits per tree and fruit yield (kg/plant and q/ha) might be attributed due to increasing levels of nutrients near the assimilating area of plant enhanced the rate of dry matter production and its rational partitioning to economic part improved the yield (Dalal *et al.*, 2004).

The above results are in conformity with the findings of Patil *et al.*, (2005) [11], Yadav *et al.*, (2011) [15] in mango, Baviskar (2011) [2] in sapota, Mahendra and Singh (2009a) [7] in ber, Pilania *et al.*, (2010) [12], Barne (2011) [1] and Godage (2012) [4] in guava and Dheware and Waghmare (2009) [3] and Dheware *et al.*, (2010) in sweet orange.

The maximum TSS was recorded with T_{13} (70% N + 85% P_2O_5 + *Azotobacter* + PSB) *i.e.* 21.43% and it was at par with treatments T_6, T_7, T_8, T_9, T_{10} and T_{12}. Likewise, the treatment T_{13} (70% N + 85% P_2O_5 + *Azotobacter* + PSB) recorded highest total sugar percentage *(*18.82%) and reducing sugars (8.80%) as compared to control. While, non reducing sugar *(*10.30%) was significantly highest under the treatment 100% N + 85% P_2O_5 + *Azotobacter* + PSB (T_6) and it was at par with T_8 followed by T_4, T_{12}, T_{13}, T_{10}, T_3, T_7 and T_5.

Significantly the maximum ascorbic acid (42.76 mg/100 g of pulp) was recorded by treatment T_{13} *i.e.* 70% N + 85% P_2O_5 + *Azotobacter* + PSB and it remained at par with treatment T_{10} followed by T_{12}. While, significantly minimum acidity (0.129%) was recorded in the treatment T_{10} (85% N + 85% P_2O_5 + *Azotobacter* + PSB) as compared to other treatments, except the treatment T_{13}.

Application of nitrogen fixing bacteria along with lower dose of inorganic fertilizers might have exhibited regulatory role on the absorption and translocation of various metabolites, in which carbohydrates are most important which affects the quality of fruits. During ripening of fruits, the reserve carbohydrates and hydrolyzed into sugars resulted in better fruit quality (Singh and Singh 2009).

These observations are in agreement with findings of Patil *et al.*, (2005) [11], Yadav *et al.*, (2011) [15] in mango, Yadav *et al.*, (2009) in aonla, Baviskar (2011) [2] in sapota, Mahendra and Singh (2009a) [7] in ber and Shukla *et al.*, (2009) [13], Pilania *et al.*, (2010) [12], Barne (2011) [1] and Godage (2012) [4] in guava.

Table 1: Chemical properties of the experimental soil

Sr. No.	Soil characteristics	Value
1.	Organic carbon (%)	0.34
2.	Available nitrogen (kg ha^{-1})	260.37
3.	Available phosphorus (kg ha^{-1})	21.84
4.	Available potash (kg ha^{-1})	415.71
5.	Soil pH (1:2.5, soil : water ratio)	7.08
6.	EC (dsm^{-1})	0.29

Table 2: The treatment details in the present investigation are as under

Sr. No.	Treatments	Treatment details
T_1	Control - 750 N + 160 P_2O_5 g/tree (RDF)	Control - 750 N + 160 P_2O_5 g/tree (RDF) (100% N + 100% P_2O_5)
T_2	100% N + 100% P_2O_5 + *Azotobacter*	750 N g/tree + 160 P_2O_5 g/tree + *Azotobacter* (5ml/tree)
T_3	100% N + 100% P_2O_5 + PSB	750 N g/tree + 160 P_2O_5 g/tree + PSB (5ml/tree)
T_4	100% N + 100% P_2O_5 + *Azotobacter* + PSB	750 N g/tree + 160 P_2O_5 g/tree + *Azotobacter* (5ml/tree) + PSB (5ml/tree)
T_5	100% N + 85% P_2O_5 + PSB	750 N g/tree + 136 P_2O_5 g/tree + PSB (5ml/tree)
T_6	100% N + 85% P_2O_5 + *Azotobacter* + PSB	750 N g/tree + 136 P_2O_5 g/tree + *Azotobacter* (5ml/tree) + PSB (5ml/tree)
T_7	85% N + 100% P_2O_5 + *Azotobacter*	637.5 N g/tree + 160 P_2O_5 g/tree + *Azotobacter* (5ml/tree)
T_8	85% N + 100% P_2O_5 + *Azotobacter* + PSB	637.5 N g/tree + 160 P_2O_5 g/tree + *Azotobacter* (5ml/tree) + PSB (5ml/tree)
T_9	85% N + 85% P_2O_5 + PSB	637.5 N g/tree + 136 P_2O_5 g/tree + PSB (5ml/tree)
T_{10}	85% N + 85% P_2O_5 + *Azotobacter* + PSB	637.5 N g/tree + 136 P_2O_5 g/tree + *Azotobacter* (5ml/tree) + PSB (5ml/tree)
T_{11}	70% N + 100% P_2O_5 + *Azotobacter*	525 N g/tree + 160 P_2O_5 g/tree + *Azotobacter* (5ml/tree)
T_{12}	70% N + 100% P_2O_5 + *Azotobacter* + PSB	525 N g/tree + 160 P_2O_5 g/tree + *Azotobacter* (5ml/tree) + PSB (5ml/tree)
T_{13}	70% N + 85% P_2O_5 + *Azotobacter* + PSB	525 N g/tree + 136 P_2O_5 g/tree + *Azotobacter* (5ml/tree) + PSB (5ml/tree)

Table 3: Flowering and fruit set parameters of mango cv. Amrapali as influenced by bio-fertilizers in combination with chemical fertilizers

Sr. No.	Treatments	No. of days taken to emergence of flowering	No. of days taken to 50% flowering	No. of panicles per branch	Length of panicle (cm)	No. of flowers per panicle	Sex ratio	Fruit set per panicle	Fruit retention per panicle
T_1	Control - 750 N + 160 P_2O_5 g/tree (RDF)	186.63	27.75	5.75	23.50	1470.63	1.50	141.60	2.60
T_2	100% N + 100% P_2O_5 + *Azotobacter*	183.00	28.50	6.63	26.38	1520.25	1.38	159.73	3.13
T_3	100% N + 100% P_2O_5 + PSB	183.00	29.50	6.75	30.13	1527.50	1.28	155.98	2.70
T_4	100% N + 100% P_2O_5 + *Azotobacter* + PSB	184.25	29.63	7.50	30.13	1606.25	0.95	175.33	3.68
T_5	100% N + 85% P_2O_5 + PSB	183.50	26.88	7.50	30.00	1570.63	1.20	167.43	3.65
T_6	100% N + 85% P_2O_5 + *Azotobacter* + PSB	183.37	26.75	7.75	33.88	1682.50	0.93	181.25	3.60
T_7	85% N + 100% P_2O_5 + *Azotobacter*	183.50	27.75	6.25	36.63	1558.13	1.10	169.43	3.45
T_8	85% N + 100% P_2O_5 + *Azotobacter* + PSB	182.00	22.88	8.88	41.50	1764.13	0.74	197.00	4.35
T_9	85% N + 85% P_2O_5 + PSB	184.75	26.13	7.38	37.63	1595.63	1.08	171.63	3.65
T_{10}	85% N + 85% P_2O_5 + *Azotobacter* + PSB	181.75	21.38	9.38	43.38	1779.38	0.73	201.33	4.70
T_{11}	70% N + 100% P_2O_5 + *Azotobacter*	186.13	25.38	6.25	42.38	1550.38	1.15	159.85	3.60
T_{12}	70% N + 100% P_2O_5 + *Azotobacter* + PSB	186.13	27.63	8.13	37.88	1728.13	0.83	189.95	4.28
T_{13}	70% N + 85% P_2O_5 + *Azotobacter* + PSB	181.13	25.38	9.13	39.38	1760.13	0.79	193.93	4.38

S.Em ±	1.72	0.86	0.38	0.94	38.19	0.06	4.14	0.21
C. D. (P =0.05)	N.S.	2.42	1.08	2.65	107.58	0.18	11.65	0.58
C. V. (%)	2.72	9.80	14.32	8.21	7.17	18.24	7.23	15.96

Table 4: Physical and yield parameters of mango cv. Amrapali as influenced by bio-fertilizers in combination with chemical fertilizers

Sr. No.	Treatments	Fruit length (cm)	Fruit diameter (cm)	Marketable fruit weight (g)	Peel weight (g)	Pulp weight (g)	Stone weight (g)	Number of fruits per tree	Fruit yield (kg/tree)	Fruit yield (q/ha)
T_1	Control - 750 N + 160 P_2O_5 g/tree (RDF)	9.87	5.41	132.38	38.25	63.25	30.88	341.00	36.63	57.14
T_2	100% N + 100% P_2O_5 + *Azotobacter*	10.21	5.41	146.23	37.12	74.63	34.47	351.13	37.88	59.09
T_3	100% N + 100% P_2O_5 + PSB	10.28	5.57	153.18	34.87	85.00	33.30	361.00	38.38	59.87
T_4	100% N + 100% P_2O_5 + *Azotobacter* + PSB	11.30	6.01	164.11	31.75	102.00	30.36	367.68	46.00	71.76
T_5	100% N + 85% P_2O_5 + PSB	10.03	5.71	151.43	35.50	80.63	35.30	359.88	37.38	58.31
T_6	100% N + 85% P_2O_5 + *Azotobacter* + PSB	11.43	6.16	160.91	34.75	97.75	28.41	401.38	41.25	64.35
T_7	85% N + 100% P_2O_5 + *Azotobacter*	10.51	5.67	152.89	38.00	82.88	32.01	360.63	37.50	58.50
T_8	85% N + 100% P_2O_5 + *Azotobacter* + PSB	11.59	6.45	166.95	32.25	105.00	29.70	541.75	52.13	81.32
T_9	85% N + 85% P_2O_5 + PSB	10.73	5.50	151.55	33.50	83.00	35.05	371.00	38.14	59.48
T_{10}	85% N + 85% P_2O_5 + *Azotobacter* + PSB	11.84	6.49	179.21	31.25	114.75	33.21	556.00	54.00	84.24
T_{11}	70% N + 100% P_2O_5 + *Azotobacter*	10.43	5.85	143.08	37.50	68.13	37.45	354.50	42.13	65.72
T_{12}	70% N + 100% P_2O_5 + *Azotobacter* + PSB	11.49	6.26	155.11	28.13	96.50	30.49	432.75	47.63	74.30
T_{13}	70% N + 85% P_2O_5 + *Azotobacter* + PSB	11.57	6.30	160.83	28.00	101.75	31.08	483.63	53.13	82.88
S.Em ±		0.29	0.13	4.27	1.33	3.49	1.60	15.03	2.00	3.12
C. D. (P =0.05)		0.80	0.36	12.02	3.75	9.74	4.52	42.35	5.64	8.80
C. V. (%)		7.48	6.03	8.23	11.79	11.56	14.18	10.99	13.92	13.92

Table 5: Quality parameters of mango cv. Amrapali as influenced by bio-fertilizers in combination with chemical fertilizers

Sr. No.	Treatments	Total Soluble Solids (%)	Total sugar (%)	Reducing sugar (%)	Non-reducing sugar (%)	Ascorbic acid (mg/100g of pulp)	Acidity (%)
T_1	Control - 750 N + 160 P_2O_5 g/tree (RDF)	17.56	16.35	7.21	9.13	36.15	0.162
T_2	100% N + 100% P_2O_5 + *Azotobacter*	17.66	16.89	7.52	9.37	37.44	0.158
T_3	100% N + 100% P_2O_5 + PSB	18.72	16.95	7.35	9.60	35.56	0.162
T_4	100% N + 100% P_2O_5 + *Azotobacter* + PSB	19.56	17.74	7.60	10.14	37.58	0.146
T_5	100% N + 85% P_2O_5 + PSB	19.03	17.08	7.54	9.54	36.99	0.162
T_6	100% N + 85% P_2O_5 + *Azotobacter* + PSB	20.56	18.30	7.99	10.30	39.32	0.150
T_7	85% N + 100% P_2O_5 + *Azotobacter*	21.06	17.50	7.93	9.57	40.23	0.164
T_8	85% N + 100% P_2O_5 + *Azotobacter* + PSB	20.72	18.36	8.13	10.22	39.44	0.143
T_9	85% N + 85% P_2O_5 + PSB	20.28	16.72	7.45	9.27	40.23	0.154
T_{10}	85% N + 85% P_2O_5 + *Azotobacter* + PSB	21.13	18.37	8.39	9.97	41.95	0.129
T_{11}	70% N + 100% P_2O_5 + *Azotobacter*	19.98	16.99	8.06	8.93	40.20	0.152
T_{12}	70% N + 100% P_2O_5 + *Azotobacter* + PSB	20.96	18.29	8.22	10.08	40.60	0.136
T_{13}	70% N + 85% P_2O_5 + *Azotobacter* + PSB	21.43	18.82	8.80	10.02	42.76	0.132
S.Em ±		0.49	0.29	0.14	0.29	0.77	0.002
C. D. (P =0.05)		1.38	0.82	0.40	0.83	2.16	0.006
C. V. (%)		7.51	4.82	5.19	8.82	5.94	4.43

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