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TOXICOLOGICAL ASSESSMENT OF CARBENDAZIM ON GROWTH, REPRODUCTION AND YIELD OF *Pisum sativum*.L

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ABSTRACT

The present study was conducted to assess the toxicological effects of carbendazim on growth, reproduction and yield of *Pisum sativum* L. taking its varieties IPF-99-25 (Adarsh) and IPFD-1-10 (Prakash). The healthy seeds of both varieties of *Pisum sativum* were treated with 0.1%, 0.2%, 0.3%, 0.4% and 0.5% concentration of carbendazim before sowing in the experimental field. The obtained plants were considered as M_1 generation. The seeds obtained from M_1 generation were further treated with corresponding concentration of carbendazim and sown in experimental plot to obtain M_2 generation. Observation showed no significant toxicological effects on germination, seedling survival, height of the plant and no. of pods upto 0.3% treatment concentration of carbendazim. There is an increasing trends of deleterious effects with increasing the treatment concentration above 0.3% on growth parameters in both varieties. However, no. of pods per plant were continuously decreasing with increasing the treatment concentration in all the dozes of carbendazim taken for study in M_2 generation. In M_1 generation, the no. of pods were deleteriously affected above 0.3% treatment concentration. The weight of the seeds were continuously decreasing with increasing the treatment concentration in both these varieties in both (M_1 & M_2) generations. As no. of pods and weight of seeds together decides the yield, the yield showed decreasing trends with increasing the treatment concentration effectively above 0.3% treatment concentration of carbendazim which clearly reflect the toxicological effects of carbendazim on *Pisum sativum* L.

KEYWORDS: *Pisum sativum*, Carbendazim, Yield

Legumes are one of the important component of Indian diet. Legumes help to improve the protein intake of human meal. Sharma & Bohera (2009) reported that legumes contribute a lot towards nitrogen economy in cereal based cropping system.

Pisum sativum (pea) are a significant vegetable and pulse crop which belong to the Fabaceae family and the Papilionaceae subfamily. *Pisum sativum* is a cool season crop mainly grown during winter season in plains and during summer season in hills. Major area of garden pea is in temperate and subtropical regions of the country. It is also grown in some cooler parts of southern India.

Despite their potential in agriculture, pea crops continue facing challenges from weed competition, insect attacks, disease incidence, unpredictable productivity and unsuccessful nodulation (Kumar *et al*., 2017).

Agrochemicals are frequently used to control pests that damage crops and decrease their quality and yield. However, growing concerns about their negative effects on health and the environment have led to efforts to find safer and more sustainable alternatives (Compant *et al*., 2005).

Several studies have emphasized the adverse affects of continuous application of synthetic chemical pesticides including health hazards, undesirable side effects and environmental pollution.The intensive pesticide application in food crops, such as rice, has led to widespread health issues among farmers in Asia (Antle and Pingali, 1994). Furthermore, for the purpose to reduce these risks, Bazzi *et al*. (2009), highlighted the importance of carefully controlling the spraying concentrations of dithiocarbamate fungicides to mitigate these risks.

According to Neelamegam *et al*. (2007), the seed germination and growth parameters of black gram were adversely affected by increasing concentrations of fungicides. The effects were more pronounced for seeds treated for 24 hours as compared to 6 hours. Buts *et al*. (2013) and Ampofo *et al*. (2009) have also reported that the careless application of agrochemicals on farms has shown negative impact on soil microflora, which in turn impacts food production.

Anne-Noe"lle petit *et al* (2012) observed that fungicides constitute one of the most effective and integrative method to control diseases against phytopathogenic fungus in agriculture. Sharma (2011) reported the deleterious effect of carbendazim on non-target micro-organism, however it is found that chemicals shows quick disease control over bio-control agents.

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According to Kumari *et al* (2024), Karathane (61.53%) was the best treatment to manage powdery mildew disease followed by hexaconazole (57.69%), wettable sulphur (53.85%), tebuconazole (50.00%), propiconazole (46.14%) and tridemorph (42,30%) over untreated unsprayed plots.

Several workers have reported the effect of different fungicides on different plants taking few characters for study. But none have studied the effects of fungicides on the whole life cycle of the plant. The purpose of the present study is to evaluate the toxicological effect of different concentrations of carbendazim on seed germination, vegetative & reproductive growth parameters along with yield of *Pisum sativum* taking its' two varities viz. IPF-1-10 (Prakash) and IPFD-99-25 (Adarsh) in M_1 & M_2 generations.

METERIALS AND METHODS

The plant material taken for study is *Pisum sativum* (Pea) having chromosome no.2n = 14. The seeds of its' two varieties IPFD-1-10 (Prakash) and IPF-99-25 (Adarsh) is procured from Indian Institute of Pulses Research, Kanpur. Chemical fungicide Carbendazim is used to assess its' toxic effect in vivo on these two varieties of *Pisum sativum.* The treatment concentration are 0.1%, 0.2%, 0.3%, 0.4% and 0.5%. Carbendazim is an organometallic compound used as fungicides.

Healthy seeds with equal size & shape were selected for treatment with carbendazim. Dry dormant seeds were first soaked in water for six hour and thereafter hundred seeds were placed in separate petridishes containing concentration 0.1%, 0.2%, 0.3% 0.4% and 0.5% of carbendazim for three hours in laboratory. Then treated seeds were sown in the well maintained experimental plots under protect in lines keeping a distance of 10 cm between the plants and 30 cm between the lines. 100 seeds soaked in water for six hour were sown in the experimental plot as control.

In the field, emergence of hypocotyle & cotyledons above the surface of the soil was taken as an index of germination. Arrangement was made for regular weeding & irrigation. Neither chemical fertilizer nor any other chemical was used to avoid confusion. The seeds were sown in the field before mid of the November and harvesting was done within a period of March to April. In between that morphological and reproductive character were studied with respect to plant height, number of branch per plant, period of harvesting, number of pods per plant etc. Height of the plant was recorded at the time of maturity. After harvesting, weight of hundred seeds were recorded from control as well as from the treated plants. This was considered as M_1 generation. Mature seeds of M_1 generation from the plants treated with different concentrations were harvested separately. These seeds were used next year in the same way after giving treatment with corresponding concentration of carbendazim taken for study and resulted crop was considered as M_2 generation. Morphological characters were recorded in M_1 & M_2 generations and finally the phenotypic variability and pod productivity were calculated. Raw data collected is compiled by standard statistical method. We calculate the means of the observed data and find out the standard deviation to draw conclusion.

RESULTS AND DISCUSSION

Result obtained in present investigation have been sown in table 1 to 4 and graph 1 to 6 and express together with discussion in separate heading as under:--

Effects on Seeds Germination

The germination percentages of variety IPFD-1-10 were 94%, 93%, 94%, 92%, & 86% in 0.1%, 0.2%, 0.3% 0.4% and 0.5% treatment concentration of carbendazim respectively in M_1 generation. In M_2 generation, it were 92%, 93%, 90%, 88%, and 86% while it were 94% and 92% under control in M_1 and M_2 generation respectively. However the germination percentages of another variety IPF-99-25 were 93%, 94%, 93%, 91%, & 87% in 0.1%, 0.2%, 0.3% 0.4% and 0.5% treatment concentration of carbendazim respectively in M_1 generation. In M_2 generation, it were 93%, 93%, 92%, 90%, and 87% while it were 94% and 92% under control in M_1 and M_2 generation respectively. Thus it is clear from the observed data that there is no significant effect on germination percentage in both generations in both varieties of *Pisum sativum* upto 0.3% treatment concentration. But the germination percentage is decreasing with increasing the treatment concentration of carbendazim above 0.3% in the both varieties in both M_1 & M_2 generations. This reflect the toxic effect of carbendazim, above 0.3% treatment concentration on germination of *Pisum sativum* in comparison to control (Fig-1).

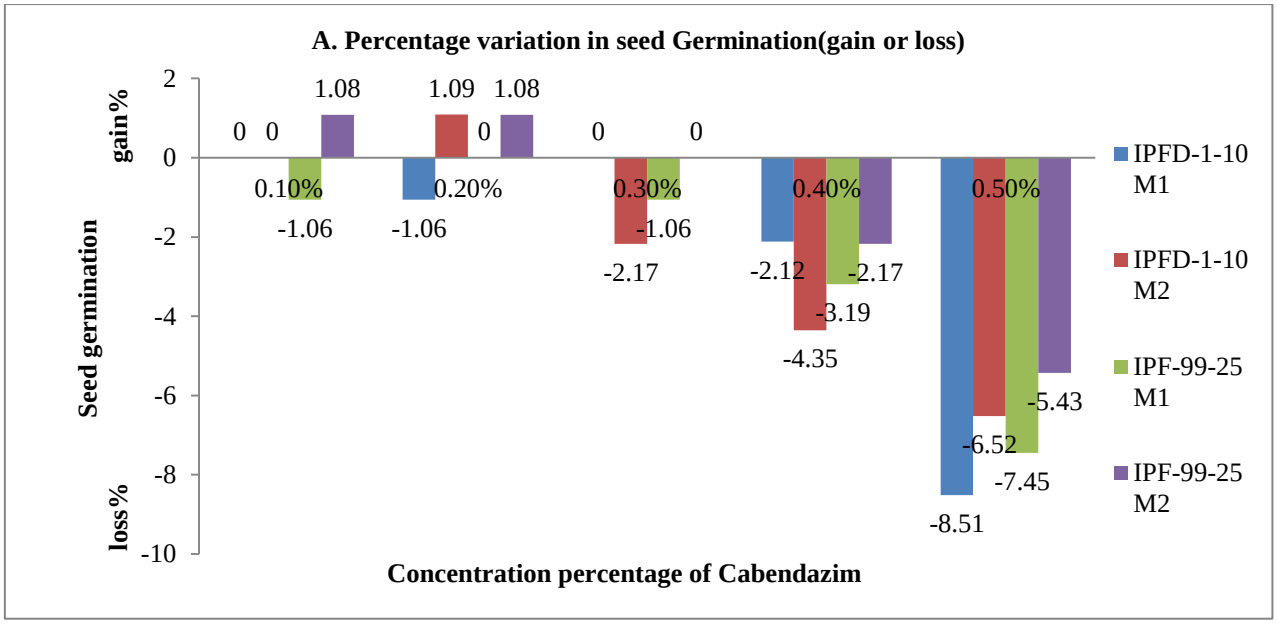

Figure 1: Percentage variation in germination of *Pisum sativum* treated with carbendazim in respect to control in M_1 & M_2 generation.

Table 1: Effect of carbendazim on quantitative characters of *Pisum sativum* variety IPFD-1-10 in M_1 generation

Treatments (Carbendazim)	Germination of Seeds in the field	Seedling Survival	Height (cm) ± SD	Number of Branches per plant ± SD	Days taken for 1st flowering	Period of harvesting (in days)	No. of Pods/ Plant ± SD	Weight of 100 seeds (gram)± SD
0.1%	94	92 %	102.06±14.64	4.27±2.64	71-79	125-130	9.03±6.71	17.88±0.10
0.2%	93	90 %	108.88±13.47	4.59±1.84	71-81	125-130	11.35±8.41	17.64±0.35
0.3%	94	90 %	106.61±16.17	4.33±1.83	71-79	125-130	11.37±11.06	18.40±0.24
0.4%	92	87 %	94.58±19.25	3.04±1.54	70-78	126-131	9.05±6.47	18.40±0.24
0.5%	86	83 %	89.12±17.64	2.96±1.38	71-79	126-131	9± 8.37	17.16±0.53
Control	94	92 %	108.55±24.19	3.09±0.83	71-79	131-136	9.28±3.30	18.70±0.02

Table 2: Effect of carbendazim on quantitative characters of *Pisum sativum* varieties IPFD-1-10 in M_2 generation

Treatments (Carbendazim)	Germination of Seeds in the field	Seedling Survival	Height (cm) ± SD	Number of Branches per plant ± SD	Days taken for 1st flowering	Period of harvesting (in days)	No. of Pods/ Plant ± SD	Weight of 100 seeds (gram)± SD
0.1%	92	92 %	103.36±14.90	3.11±0.96	75-84	133-138	8.33±5.54	18.20±0.06
0.2%	93	92 %	96.64±17.35	3.05±0.92	75-84	133-138	8.57±4.01	18.11±0.20
0.3%	90	89 %	93.80±14.50	3.29±0.87	75-84	133-138	7.80±3.18	18.09±0.20
0.4%	88	85 %	88.87±13.05	2.86±1.13	75-84	133-138	7.80±1.23	17.82±0.11
0.5%	86	84 %	78.93±15.26	3.16±0.95	75-84	133-138	6.86±2.67	17.17±0.20
Control	92	91 %	107.06±11.42	3.16±0.53	75-84	138-142	8.7±3.52	18.28±0.11

Table 3: Effect of carbendazim on quantitative characters of *Pisum sativum* variety IPF-99-25 in M_1 generation

Treatments (Carbendazim)	Germination of Seeds in the field	Seedlin Survival	Height (cm) ± SD	Number of Branches per plant ± SE	Days taken for 1st flowering	Period of harvesting (in days)	No. of Pods/ Plant ± SD	Weight of 100 seeds (gram)± SD
0.1%	93 %	92 %	209.58±55.12	6.75±2.24	71 -80	129-136	15.5 ±10.20	18.14±0.13
0.2%	94 %	90 %	230.86±46.47	7.43±2.33	71- 80	129-136	16.54±9.45	17.87±0.06
0.3%	93 %	89 %	211.12±51.56	8.21±3.13	71-80	129-136	16.40±11.23	17.60±0.03
0.4%	91 %	87 %	199.20±42.39	6.67±2.65	72- 81	129-136	14.27.88±9.46	17.31±0.12
0.5%	87 %	82 %	187.21±30.80	6.48±2.12	74-82	129-136	12.88±9.46	17.24±0.16
Control	94 %	92 %	206.39±48.60	6.30±2.70	71-80	129-136	15.69±9.93	18.99±0.16

Table 4: Effect of carbendazim on quantitative characters of *Pisum sativum* variety IPF-99-25 in M_2 generation

Treatments (Carbendazim)	Germination Of Seeds in the field	Seedling Survival	Height (cm) ± SD	Number of Branches per plant ± SD	Days taken for 1st flowering	Period of harvesting (in days)	No. of Pods/ Plant ± SD	Weight of 100 seeds (gram)± SD
0.1%	93%	92 %	205.3±31.49	6.44±1.95	80-88	139-146	14.42±2.35	17.43±0.17
0.2%	93%	92 %	196.05±32.14	6.49±1.42	78-86	139-146	16.50±3.16	17.25±0.17
0.3%	92%	90 %	188.93±24.39	6.78±1.31	82-88	139-146	14.95±3.07	16.91±0.10
0.4%	90%	86 %	179.53±28.40	5.98±1.66	82-88	139-146	14.20±2.73	16.50±0.38
0.5%	87%	81 %	162.55±25.44	4.05±1.65	83-89	139-146	13.78±2.52	15.43±13.95
Control	92%	91 %	207.70±30.10	6.16±1.10	78-86	142-147	15.18±3.01	17.87±0.12

Effect on Seedling Survival

The seedling survival percentage of variety IPFD-1-10 & IPF-99-25 were 92%, 90%, 90%, 87% & 83% and 92%, 90%, 89%, 87% & 82% respectively in 0.1%, 0.2%, 0.3%, 0.4%, and 0.5% treatment concentration of carbendazim in M_1 generation. It was 92% in control in both varieties. In M_2 generation, it were 92%, 92%, 89%, 85% & 84% and 92%, 92%, 90%, 86% & 81% of variety IPFD-1-10 & IPF-99-25 respectively in 0.1%, 0.2%, 0.3%, 0.4% & 0.5% treatment concentration. It was 91% in control in both varieties of *Pisum sativum.* Thus, it is clear that deleterious effect on seedling survival increases with increasing the treatment concentration above 0.2% in both generations in both varieties of *pisum sativum* taken for study (Fig.2).

Effect on Height of The Plants

The average height of the plants of variety IPFD-1-10 (Prakash) were 102.06 cm, 108.88 cm, 106.61 cm, 94.58 cm & 89.12 cm in M_1 generation and 103.36 cm, 96.64 cm, 93.80 cm, 88.87 cm & 78.93 cm in M_2 generation in 0.1%, 0.2%, 0.3%, 0.4% & 0.5% treatment concentration of carbendazim respectively in comparison to 108.55 cm in M_1 & 107.06 cm in M_2 under control.

The average height of the plants in variety IPF-99-25 were 209.58 cm, 230.86 cm, 211.12 cm, 199.20 cm & 187.21 cm in M_1 generation and 205.3 cm, 196.05 cm, 188.93 cm, 179.53 cm & 162.55 cm in M_2 generation in 0.1%, 0.2%, 0.3%, 0.4% & 0.5% treatment concentration of carbendazim respectively in comparison to 206.39 cm & 207.70 cm respectively in control.

The critical analysis of data clearly showed a decrease of 1.78%, 12.86% & 17.89% in average height in variety IPFD-1-10 in 0.3%, 0.4% & 0.5% treatment concentration treated crop respectively in M_1 generation in comparison to control. In M_2 generation, there were a decrease of 3.46%, 9.73%, 12.32%, 16.99% & 26.27% in the average height in 0.1%, 0.2%, 0.3%, 0.4% & 0.5% treatment concentration treated crops respectively in comparison to control. In variety IPF-99-25, the average height decreased with 3.48% & 9.29% in 0.4% & 0.5% concentration of carbendazem treated crops respectively in M_1 generation in comparison to control. In M_2 generation, the average height of the plant decreased with 5.61%, 9.04%, 13.56% & 21.74% in 0.2%, 0.3%, 0.4% & 0.5% concentration of carbendazim treated crops respectively in comparison to control (Fig. 3). Thus, there is a significant deleterious effect of carbendazim on

Pisum sativum at above 0.2% treatment concentration which increases with increase in the treatment concentrations (Fig.3).

Effect on Number of Branche Per Plant

Average number of branches in variety IPFD-1-10 in M_1 generation were 4.27, 4.59, 4.33, 3.04 and 2.96 in 0.1%, 0.2% 0.3% 0.4% and 0.5% treatment concentration of carbendazim respectively in comparison to 3.09 in control. Similarly in M_2 generation, the value for the same treatment concentration were 3.11, 3.05, 3.29, 3.16, and 2.86 respectively in comparison to 3.16 in control. Average number of branches in variety IPF-99-25 in M_1 generation were 6.75, 7.43, 8.21, 6.67 and 6.48 in 0.1%, 0.2% 0.3% 0.4% and 0.5% concentration treatment of carbendazim respectively in comparison to 6.30 in control. In M_2 generation, the value for the same treatment concentration were 6.44, 6.49, 6.78, 5.98, and 4.05 respectively in comparison to 6.16 in control.

Thus, there is an inducive effect regarding the branching in both varieties in both M_1 & M_2 generations upto 0.3% treatment concentration. Thereafter, the number of branches reduces with increasing the treatment concentration(Fig.4).

Effect on Days Taken for Initiation of 1st Flowering

There is no significant difference between the days taken for initiation of flowering in different treatment concentration of carbendazim under taken for study in both variety of *Pisum sativum* in both generations.

Effect of Period of Harvesting

The period of harvesting were slightly less in treated plants in comparison to control in both varieties of *pisum sativum* in both generations. Conclusively, more or less, there was no significant effect in both varities of *Pisum sativum.*

Effect on Number of Pods Per Plant

The average number of pods per plant in variety IPFD-1-10 were 9.03, 11.35, 11.37, 9.05 & 9 in 0.1%, 0.2%, 0.3%, 0.4%, and 0.5% treatment concentration of carbendazim respectively in comparison to 9.28 under control in M_1 generation. In M_2 generation, the average number of pods are 8.33, 8.57, 7.80, 7.80 & 6.86 in 0.1%, 0.2%, 0.3%, 0.4% and 0.5% treatment concentration respectively in comparison to 8.7 under control. However in second variety IPF-99-25, the average number of pods per plant was 15.5, 16.54, 16.40, 14.27 & 12.88 in 0.1%, 0.2%, 0.3%, 0.4% and 0.5% treatment concentration of carbendazim respectively in comparison to 15.69 under control in M_1 generation. In M_2 generation, the average number of pods were 14.42, 16.50, 14.95, 14.20 & 13.78 in 0.1%, 0.2%, 0.3%, 0.4% and 0.5% treatment concentration of carbendazim respectively in comparison to 15.18 under control. Thus, observations clearly reflect the deleterious effect in above 0.3% treatment concentration of carbendazim treated plants (Fig.5).

Effect on Weight of Seeds

In IPFD-1-10 variety, weight of 100 seeds are 17.88 gram, 17.64 gram, 18.40 gram, 18.40 gram & 17.16 gram in 0.1%, 0.2%, 0.3%, 0.4% and 0.5% treatment concentration of carbendazim treated plants respectively in M_1 generation. In M_2 generation, weight of 100 seeds are 18.20 gram, 18.11 gram, 18.09 gram, 17.82 gram & 17.17 gram in 0.1%, 0.2%, 0.3%, 0.4% and 0.5% treatment concentration respectively. While in control, it is 18.70 gram & 18.28 gram in M_1 and M_2 generation respectively. However, in second variety IPF-99-25, the average weight of 100 seeds are 18.14 gram, 17.87 gram, 17.60 gram, 17,31 gram & 17.24 gram in 0.1%, 0.2%, 0.3%, 0.4% and 0.5% treatment concentration of carbendazim respectively in M_1 generation. In M_2 generation, weight of 100 seeds are 17.43 gram, 17.25 gram, 16.91 gram, 16.50 gram & 15.43 gram in 0.1%, 0.2%, 0.3%, 0.4% and 0.5% treatment concentration carbendazim respectively while it is 18.99 gram & 17.87 gram under control in M_1 & M_2 generation respectively. Thus the average weight of seeds reflect decreasing trends with increasing the treatment concentration of carbendazim in both generations of *Pisum sativum* in comparison to control (Fig.6).

We have assessed the toxic effects of carbendazim giving single dose treatment to seeds before sowing in the field on germination, growth parameters and productivity of *Pisum sativum* taking its two varieties IPFD-1-10 & IPF-99-25 up to two generations. On the basis of observations and above discussion, we can conclude that *Pisum sativum* can tolerate the toxic effect of carbendazim up to 0.3% treatment concentration in respect to seed germination, survival of plants, height of plants and number of pods. The weight of 100 seeds showed decreasing trends with increasing treatment concentration under taken for study in both varieties of *Pisum sativum* in both generations. Yield depends upon the number of pods per plants and weight of seeds. The toxic effects on yield of the crop increases with increasing in the treatment concentration. Thus farmer can utilize only up to 0.3% concentration of carbendazim to control the fungi. Above this dose the yield is badly affected. Thus the awareness should be raised regarding reckless use of this (carbendazim) fungicides reflecting its toxic effect which may also affect the human health through bio-magnification.

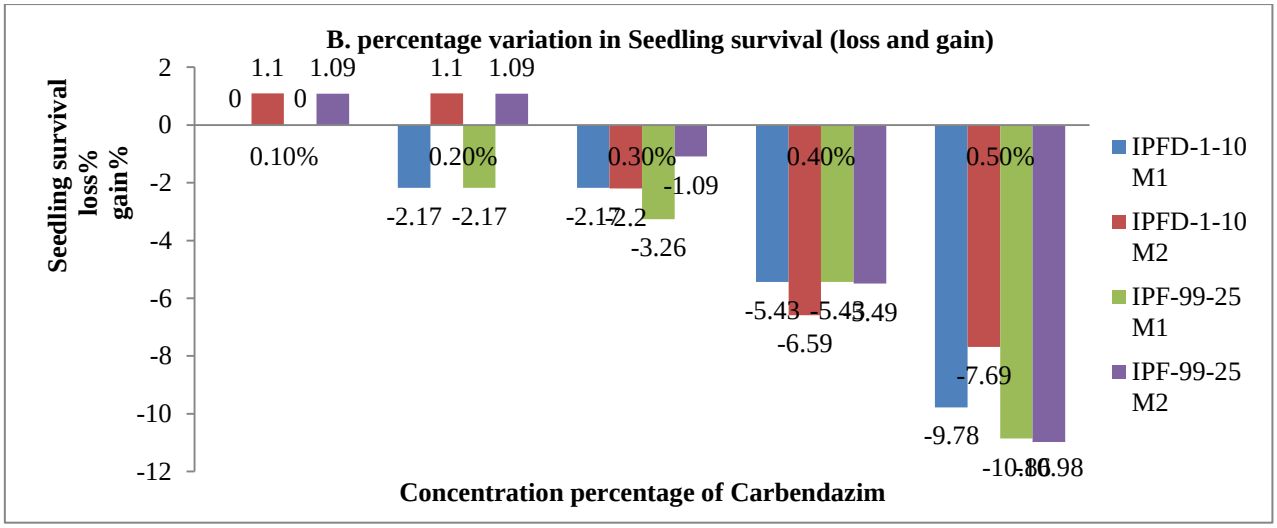

Figure 2: Percentage variation in seedling survival of *Pisum sativum* treated with carbendazim in respect to control in M_1 & M_2 generation.

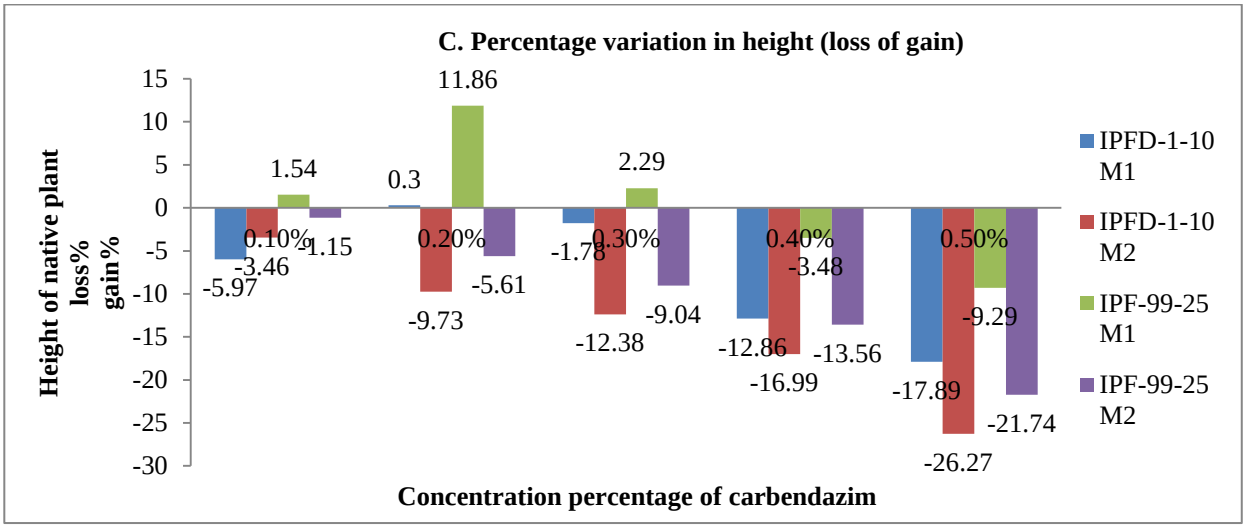

Figure 3: Percentage variation in height of *Pisum sativum* treated with carbendazim in respect to control in M_1 & M_2 generation.

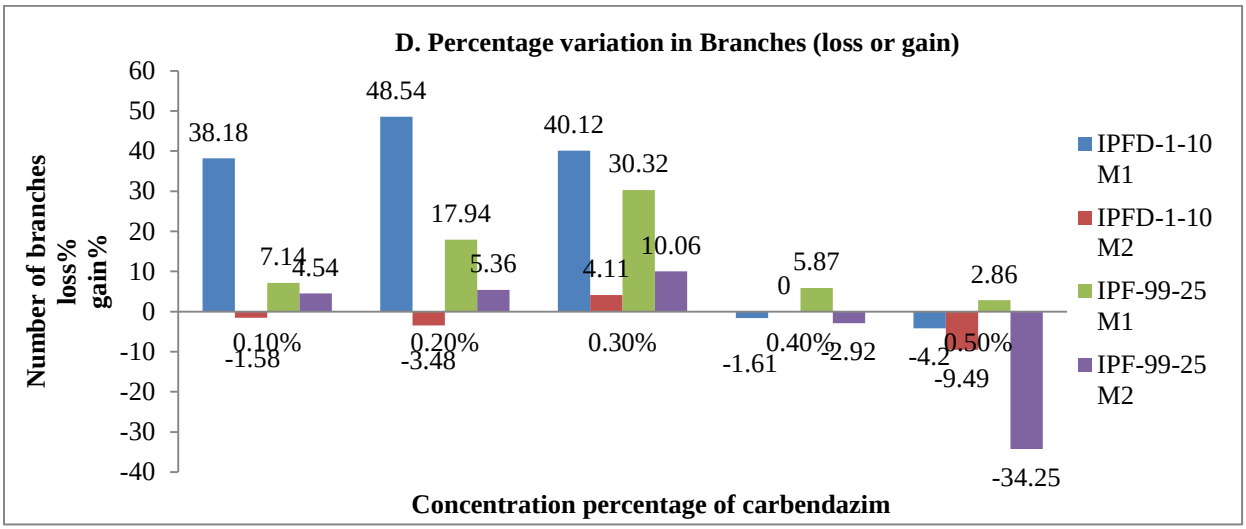

Figure 4: Percentage variation in no. of branches of *Pisum sativum* treated with carbendazim in respect to control in M_1 & M_2 generation.

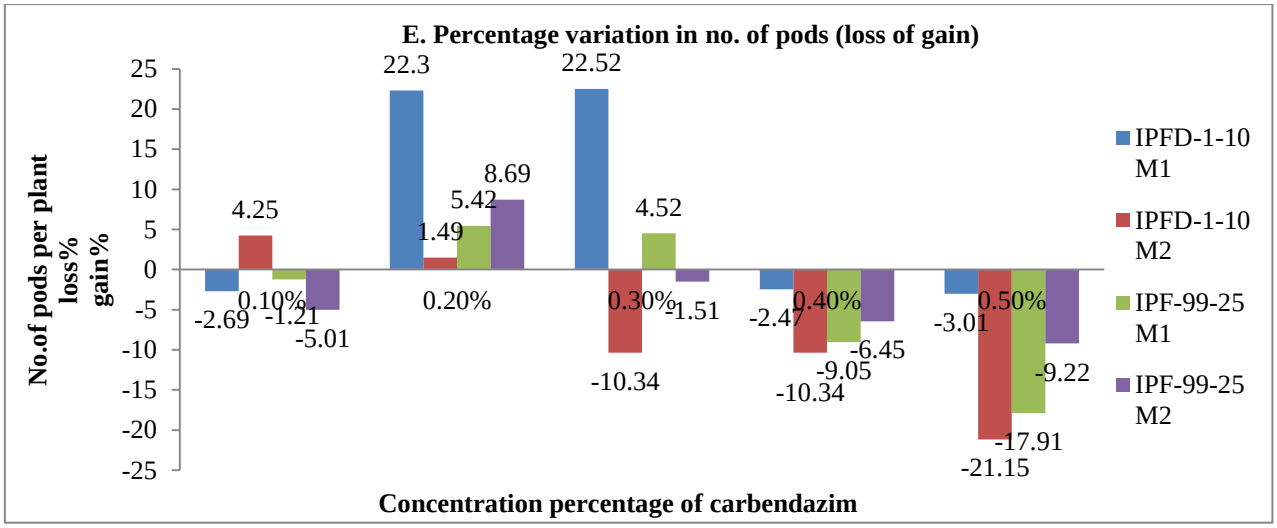

Figure 5: Percentage variation in no. of pods of *Pisum sativum* treated with carbendazim in respect to control in M_1 & M_2 generation.

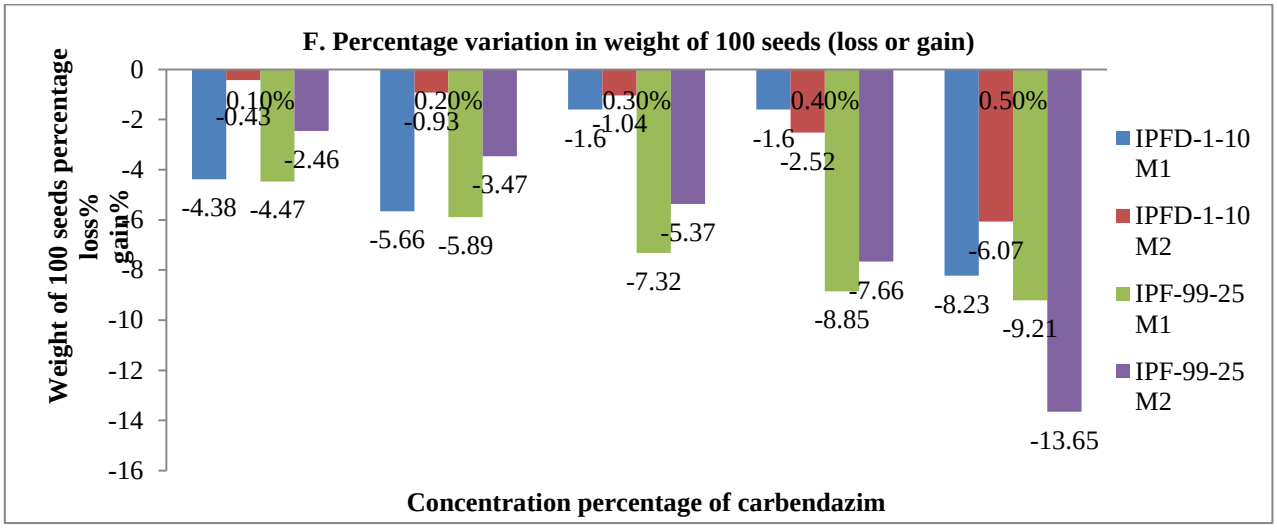

Figure 6: Percentage variation in weight of 100 seeds of *Pisum sativum* treated with cardendazim in respect to control in M_1 & M_2 generation.

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