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Kitherian Sahayaraj (ksraj48@gmail.com)
St Xavier's College Department of Zoology https://orcid.org/0000-0002-0127-8632
Suppiah Arumugavel
St Xavier's College Department of Zoology
Athirstam Ponsankar
St Xavier's College Department of Zoology
Mariappan Madasamy
St Xavier's College Department of Zoology

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Kitherian Sahayaraj[a*], Suppiah Arumugavel[a], Athirstam Ponsankar[a], and Mariappan Madasamy[a]

[a]Crop Protection Research Centre (CPRC), Department of Zoology, St. Xavier's College (Autonomous), Palayamkottai – 627002, Tamil Nadu, India

Suppiah Arumugavel (s.arumugavel1995@gmail.com)

Athirstam Ponsankar (sreeram.pons@gmail.com)

Mariappan Madasamy (madasamy18492@gmail.com)

Correspondence author

Kitherian Sahayaraj

Crop Protection Research Centre (CPRC),

Department of Zoology, St. Xavier's College (Autonomous),

Palayamkottai – 627002, Tamil Nadu, India

Email: ksraj48@gmail.com

Mobile: + 91 9443497192

ABSTRACT

To enhanced the development and reproduction of Eri silkworm incorporation of Coal Flyash Liquid (CFL) in their natural diet was developed to evaluate the growth and fecundity rate of eri silkworm. energy dispersive analysis of castor leaves treated with CFL at 10% concentration revealed the presence of five major minerals viz., magnesium (Mg), silica (Si), chlorine (Cl), potassium (K) and calcium (Ca). While CFL incorporated castor leaf enhanced the pupation rate, shell weight, cocoon shell ratio, fecundity and egg hatchability of the silkworm. In contrast, pupal weight was increased at lower concentration of CFL with a weight of 2.39 mg. A significant difference was observed in rearing performance of eri silkworm at different concentrations of CFL incorporated castor leaf. Relative growth rate of the eri silkworm was increased to 84% when larvae treated with CFL at 5% concentration. Further, CFL at the concentration of 5% enhanced the seed germination percentage and at the higher concentration of 10% increased the root-shoot ratio, relative water content and vigour index of cucumber. Similar response of increase in studied growth parameters was also observed in radish seedlings when treated with CFL. The physiochemical properties of CFL amended soil (5%) showed that available phosphorous level and potassium level was increased respectively to 9.52% and 53.92% in comparison to control. It could be concluded that minerals present in CFL may be influential and responsible for the growth of eri silkworm and seedling of cucumber and radish.

Keywords: Coal Flyash; EDAX; Mortality; Cocoon shell ratio; Relative growth rate; Root shoot ratio.

Introduction

The eri-silkworm, *Samia cynthia ricini* Boisduval, is one of the most exploited and commercialized non-mulberry silkworms. It is a multivoltine and polyphagous species which can be reared throughout the year depending on the availability of feed (Kedir et al., 2014). Fortification is a method of incorporating any nutrients for the promotion of growth, cocoon shell production and reproduction. In past, iodide, copper sulphate, streptomycin, procaine penicillin, inorganic minerals, potassium senescent tapioca leaves and cyanobacteria were incorporated for the improvement of eri silkworm rearing (Sakthivel & Qudri, 2013) . Tapioca is also considered as primary food plant of eri silkworm (Rajashekhargouda et al., 2009) . Presence of minerals in silkworm feeds is ought to be essential in sericulture. Moreover, it is observed that the silkworm which feeds on leaves having moisture of 70.6% , 29.46% of crude protein, 17.93% of minerals and 9.78% total sugars has showed better cocoon growth (Ito, 1978; Legay, 1958; Krishnaswami, 1978).

Coal is a major source of fuel for production of electricity in many countries in the world. During the combustion of coal, 70 % of fly ash is produced as solid waste where disposal becomes challenging (Roy et al., 1984; Theis & Gardner, 1990). Coal power plants produce large quantities of combustion residues including bottom ash, slag and fly ash. Fly ash is an inorganic residue with variety of elements such as Mn, B, Ba, Cu, Sr, Ni, Cr, Zn, Cd, Co, Mo, V, Se, Pb, As, etc. (Adriano et al., 1980). Studies on Fly ash has been promising in controlling insect pest (Narayanaswamy, 2010; Pradhan & Bral, 2016). However, application of fly ash as growth stimulator for insects is not available in the literature.

Based on literature, the present study was conducted to evaluate the effect of growth of eri silkworm by incorporation of fly ash on following objectives: 1) to analyse the physicochemical properties of CFL and CFL incorporated castor leaf through EDAX; 2) to

examine the growth behavioural of eri silkworm after feeding with CFL incorporated castor leaf; 3) to assess the effect of CFL amendment soil on the growth of CFL treated seeds of cucumber and radish and 4) examined the physico-chemical properties of CFL amendment soil through.

Materials and method

Collection and rearing of eri silkworm

Eri silkworm eggs (seeds) certified as disease-free laying (dfls) were procured from Seed Technology Laboratory, Central Silk Board, Salem, Tamil Nadu. Insects were maintained under laboratory conditions at 25±1 °C and 75 – 85% relative humidity with the photoperiod of 11:13 D till their hatching. The newly hatched larvae were reared on castor leaves (*Ricinus communis*). Unfed leaves and faecal pellets were removed every day before providing the next consignment of food with least disturbance to the larvae. The faecal samples were collected dried separately at 50-60 °C for gravimetric calculation purpose. Care was taken to separate fine unfed food particles from the faecal pellets. Every 24 hours, dead larvae were also removed up to third and fourth instars. Occasionally, the worms were transferred to new plastic traysand covered with wet muslin cloth when the room temperature rose above 30 °C also by by keeping the doors and windows open.

Selection of leaf for indoor feeding

The leaves of *R. communis* were collected from Papaiyapuram (latitude 9.67942 and longitude 77.81028), Tirunelveli District. The branches were cut with a sharp knife with a sloppy pointed end at the base. The young leaves were washed in clean running water to remove dust and debris. The leaves were kept in a bucket containing 5 ppm of a chemical formulation at least one hour before brushing so that the branches remain fresh for at least 16-24 hours.

Collection and preparation of fly ash particulate materials

Coal fly ash was bought from fly ash bricks shop at Pothy's Nager, Tirunelveli and were sieved finely with a mesh of size 10 × 10 mm and stored in airtight containers for further use. 100 mg of fly ash powder was taken in a beaker containing 1litre of distilled water and then centrifuged at 2000 rpm for 10 min. The supernatant was collected separately and the stored for further use. The sample was diluted with water and made up to 1.25, 2.5, 5 and 10% (CFL). To each mixture, 50 µl of 0.05% Twin 80 was added an adhesive agent and was centrifuged at 3500 rpm for 15 min. The solution was filtered with filter paper and supernatant was used as test solution. For control, adhesive agent (50 µl of 0.05% Twin 80) is mixed with 100 ml of distilled water.

Incorporation of fly ash liquid particulate materials to castor leaves

Leaves of *R. communis* were incised at oblique angle in order to increase the mineral absorption rate. The leaves were dipped in CFL solution at a concentration of 1.25, 2.5, 5 and 10% respectively and were covered with wet cotton cloth in order to reduce transpiration. The mineral absorption efficiency of CFL incorporated leaves was analyzed through EDAX.

EDAX analysis

Energy dispersive analysis of trays was used to find out the minerals present in the CFL incorporate leaves. After 72 hours of incubation the leaves were taken and dried in hot air oven at 50 °C for 24 hours. Ash obtained with help of muffle furnace (temo-1808) was tested for the presence of various elements present in FLP treated leaves.

Experimental studies on *growth amendments of eri silkworm*

Newly moulted third instars larvae were fed with CFL incorporated castor leaves of concentrations 1.25, 2.5, 5 and 10% respectively. Distilled water treated leaves served as control. After 24 hours, unfed leaves and faecal pellets were removed and fed with fresh castor leaves with least disturbance to the larvae. The collected faecal pellets and uneaten

leaves were dried separately at 50 - 60 °C for gravimetric calculation. Every 24 hours, dead larvae were collected up to third and fourth instars. Trays were covered with wet muslin cloth. Each experiment was replicated 5 times with 10 larvae for each replication. The dried leaves were weighed using 0.001mg electronic sensitive balance monopan (Dhona 160D) and recorded in order to find out energy budget parameters. The larvae were periodically measured to find the growth parameter.

Growth parameter analysis

The survival rate of CFL fed larvae was calculated using the formula:

$$\text{Survival rate (\%)} = \frac{\text{No. of larvae survived}}{\text{No. of larvae dead}} \times 100$$

The pupation rate of CFL fed larvae was calculated using the formula:

$$\text{Pupation rate (\%)} = \frac{\text{No. of larvae pupated}}{\text{No. of larvae introduced}} \times 100$$

At the fifth stage of instar, the silkworm started spinning in a cocoon. The cocoons of various concentrations were collected, incubated separately and weighed. Completely developed cocoons from various concentrations were taken and the shell was removed to calculate the shell weight and the pupal weight (Sakaguchi, 1978).

The cocoon shell ratio was calculated using the formula:

$$\text{Cocoon shell ratio (\%)} = \frac{\text{Shell weight}}{\text{Cocoon weight}} \times 100$$

Emerged adults were maintained in plastic containers (500 ml capacity) as pairs. Castor leaves was provided as an arena for egg laying. Every day, number of eggs layed by a female was recorded and fecundity was using the given formula:

$$Fecundity\ (\%) = \frac{No.\ of\ eggs\ laid\ by\ treated\ adults}{No.\ of\ eggs\ laid\ by\ control\ adults} \times 100$$

Egg hatchability was determined by the eggs laid by the adults from different concentrations (1.25, 2.5, 5 and 10%) of CFL treated larvae and compared their hatchability rate with egg hatchability ratio of control adults by the using the formula:

$$\text{Egg hatchabilty (\%)} = \frac{\text{No. of eggs hatched in treatment}}{\text{No. of eggs hatched in control}} \times 100$$

Relative growth rate

The relative growth rate (RGR) of eri silkworm was calculated at 24, 48, 72, 96 and 120 h by using the formula (Işıkberr & Copland, 2002):

$$\text{RGR} = \frac{\text{Final weight of insect} - \text{Initial weight of insect}}{(\text{Final weight of insect} + \text{Initial weight of insect})/2} \times \text{Days}$$

Gravimetry

The fourth and fifth instar larvae were provided with CFL solution (1.25, 2.5, 5.0, 10.0%) incorporate leaves as food. Control category was provided with normal leaves wish sprayed with tap water. Every day, known quantity of food was provided, and after a day unconsumed food, fecal pellet and animal weight was recorded. All weighing were analyzed using a monopan electronic balance with an accuracy of 0.001 mg. The accuracy of balance was checked for every 20 weighing. The following formulas are used to analyze the different parameters.

$$Growth(mg) = Final\ weight - Initial\ weight$$

$$Growth\ rate\ (mg) = \frac{Growth\ (mg) \times 100}{Initial\ wet\ weight \times Duration}$$

$$Food\ counsume\ rate(\%) = \frac{Dry\ food\ counsume(mg)}{wet\ weight\ gain(mg) - Animal\ weight(mg)}$$

$$Conversion\ rate(\%) = \frac{Dry\ food\ consume(mg)}{wet\ animal\ weight} \times 100$$

$$Specific\ growth\ rate(\%) \frac{Inl2 - Inl1}{Experiment\ duration(day)} \times 100$$

Where,

In-Natural log;

I2-Final live weight;

I1-Initial live weight

The food consumption of the fifth instars larvae was calculated by adding daily consumption /larva. The mean faecal weight/larva was also calculated similarly. The above quantitative estimation of C was made in terms of joules. Food energy converted into body substance (P=Growth) was estimated as the difference between the energy content of the test larvae at the beginning and at the end of fifth instar. Food assimilated (A) was calculated by subtracting the mean faecal energy from that of food energy consumed (Sakaguchi, 1978).

$$Consumption\ (C) = P + R + F + U$$

Where,

C - Food energy consumed; P – Growth;R - Energy released as heat due to metabolism;

F+U – Loss of energy through feces and nitrogenous excretory products (Işıkberr & Copland, 2002).

$$\text{Assimilation(mg)} = \text{c} - (\text{f} + \text{u})$$

Rates of consumption, Assimilation, and production were calculated by dividing the respective amounts of energy by the product of mid-body weight (g) of the worms and the duration (days) required for the completion of the fifth instar the rates were expressed in terms of mg live larva/day. Efficiencies of conversion of ingested matter to body substance (ECI) and digested matter to body substances (ECD) were calculated relating P to C and A separately and expressed as percentage (Tasida & Gobena, 2013).

$$\text{Conversion rate(\%)} = \frac{Dry\ animal\ weight(mg)}{Wet\ animal\ weight(mg)} \times 100$$

Experimental design amelioration of horticulture crops

192 The experiments were set on randomized micro-plot design with five replicates. Microplot
193 was prepared by filling the plot with soil amended with CFL at different treatment
194 concentration (1.25, 2.5, 5 and 10%). Ten plots of 4.5 × 3.8 cm (Height × width) size saving
195 margin of 2 cm between the plots were prepared. The plots were filled with control and with
196 addition of CFL (1.25, 2.5, 5 and 10%). Soil samples were collected from control and CFL
197 incorporated soils to analyze their physico-chemical properties.

198 **Seed germination**

199 Seed germination was calculated according to the procedure of Tasida and Gobena (2013).
200 Seeds of cucumber (local variety) and radish (local variety) were purchased from local
201 market. The seeds were soaked at different concentrations of CFL (1.25, 2.5, 5 and 10%) and
202 with control as distilled water. After 24 hours of incubation the seeds were filtered and placed
203 uniformly in paper roll-towel (filter medium) at room temperature (28 ± 2 °C) under dark
204 condition. Six replications were maintained for each treatment. After 7-days, seedlings from
205 roll towel were carefully removed and measured the length of roots, shoots, hypocotyl,
206 epicotyl and also the length and width of cotyledon and true leaves. Mean values were
207 calculated and expressed in cms. Seed germination percentage was calculated using the given
208 formula:

209 $$Germination(\%) = \frac{no\ of\ seeds\ germinated}{total\ of\ seeds\ sown} \times 100$$

210 **Plant sampling and analysis**

211 Ten seeds were manually sown with distilled water and CFL incorporated water (1.25, 2.5,
212 5 and 10%) for 24 hrs. Later, seeds were transferred into micro-plot filled with control
213 and CFL incorporated soils. Similar irrigation regimes were provided to each plot to keep
214 uniform moisture content. At regular intervals of 7 days (7, 14 and 21 days) the seedlings
215 were uprooted randomly from each control and treated plots. The monoliths were thoroughly
216 washed after placing them on sieves of 1mm mesh size under the running tap water to remove

217 the soil particles adhering to the root surface. The fresh plant material was used for
218 morphological studies and the plant samples were stored in refrigerator at 4 °C for further
219 analysis.

220 **Growth and yield parameters**

221 Growth parameters such as root and shoot length, and plant biomass were measured. The
222 plants were dissected in to root and shoot and oven dried at 80 °C till constant weight was
223 achieved. The plant parts were then weighed separately and biomass accumulation was
224 expressed as gram per plant. For total plant biomass dry weights of all the plant parts were
225 cumulated. Root-shoot ratio, relative water content and vigour index were calculated from the
226 biomass data using the respective formulae (Hunt, 1982).

227 $$\text{Root shoot ratio} = \frac{Root\ length}{Shoot\ length}$$

228 $$\text{Relative water content} = \frac{Fresh\ weight\ shoot - Dry\ shoot\ weight}{Total\ weight - Dry\ weight} \times 100$$

229 $$Vigour\ index = SG \times (SL + RL)$$

230 **Physico-chemical analysis**

231 The control and the CFL incorporated soil was analyzed for various physicochemical
232 parameters viz., pH, electrical conductance, available nitrogen, available phosphorous,
233 available potassium, organic carbon content and nitrogen status based on organic carbon.
234 The pH and electrical conductance of control soil and CFL incorporated soil was analyzed
235 and using the soil suspension of 1:5 (w/v) by pH meter (Model: 335, Systronics, Ahmedabad)
236 and electrical conductivity meter (Model303, Systronics, India) respectively. The amount of
237 nitrogen present in the soil was estimated using the procedure described by Allison (1955)
238 and available nitrogen was scaled accordingly as Low = < 280 kg/ha; Medium = 280 – 450
239 kg/ha and High = > 450 kg/ha. The available phosphorus (P) was quantified by $NaHCO_3$
240 extraction method given by Olsen and Sommers (1982) and available phosphorus was scaled

241 accordingly as Low = < 11 kg/ha; Medium = 11 to 22 kg/ha and High = > 22 kg/ha 2.15.3.
242 Estimation of Potassium content in the soils was determined by Halevy [18] and was scaled
243 accordingly as Low = < 118 kg/ha; Medium = 118 to 280 kg/ha; High = > 280 kg/ha.
244 Organic carbon content of of the soils was determined by Walkley and Black's rapid titration
245 method (Walkley & Black, 1934) and scaled as Low = < 0.5%; Medium = 0.5 to 0.75%;
246 High = > 0.75%

247 **Statistics**

248 All experiments were conducted in replicates and the data including environmental
249 parameters i.e temperature, relative humidity and rain fall during the crop seasons were
250 recorded in Microsoft excel and analyzed by Statistical Analysis System (SAS). Standard
251 error and significant differences between values were determined using Duncan's multiple
252 range test ($p<0.005$) following one-way ANOVA. Graphs and diagrams were represented
253 with the help of statistical software program SPSS - 20 Version.

254 **Results**

255 **EDAX analysis of coal fly ash**

256 The EDAX analysis of control leaves (Fig.1) revealed the presence of five minerals such
257 as oxygen, magnesium, silica, potassium and calcium with 17.63, 8.86, 13.40, 3.84 and
258 28.34% respectively (Table 1). But CFL treated castor leaves at a lower concentration of
259 1.25% (Fig. 2) showed presence for seven minerals such as oxygen (20.12%), magnesium
260 (2.4%), silica (6.85%), chlorine (1.38%), potassium (25.14%), calcium (11.12%) and sulphur
261 (1.07%). However, maximum percentage of minerals was observed in castor leaves which
262 were treated with CFL at 10% concentration (Fig. 3) indicating that fly ash incorporated
263 castor leaves have increased amount of minerals when compared to control leaves.

264 **Growth amendments of eri silkworm**

265 The relative growth rate of silkworm was increased when larvae was treated with fly ash
266 5% concentration (84 mg). CFL at lower concentrations of 1.25 and 2.5% showed lower
267 relative growth rate of 63.26 and 68.84 mg respectively. In addition, CFL at the higher
268 concentration of 10% also affected the relative growth rate with 59.8 mg. Control larvae
269 showed lower relative growth rate (51.32 mg) and was significant ($F_{4,10}$=17.74; P≤0.05)
270 when compared to all the treatment concentration of CFL (1.25, 2.5, 5 and 10%) (Fig. 4).
271 The CFL solutions with different concentrations (0.25, 0.5, 5 and 10%) were tested for
272 its pupation efficacy against third instar larvae of eri silkworm. The pupation rate was higher
273 at the treatment concentration of 5% followed by 10% with the rate of 91.35% and 87.03%
274 respectively (Fig. 5). In contrast, lower pupation rate was observed in control (83.03%) and it
275 was significantly different with all other treatment concentration (0.25% ($F_{4,95}$=1.67;
276 P≤0.05), 0.5% ($F_{4,95}$=1.67; P≤0.033) and 10% ($F_{4,95}$=1.67; P≤0.05)) of fly ash except at
277 1.25% ($F_{4,95}$=1.67; P≤0.999).
278 Cocoon weight was slightly lower in control (2.03 mg) and it showed significant different
279 with CFL treatments concentration of 1.25% ($F_{4,95}$=7.95; P≤0.05), 2.5% ($F_{4,95}$=7.95;
280 P≤0.011), 5% ($F_{4,95}$=7.95; P≤0.012) and 10% ($F_{4,95}$=7.95; P≤0.151). Proportionally, highest
281 cocoon weight was observed in 5% (3.33 mg) followed by 10% (2.95 mg), 2.5% (2.81 mg)
282 and 1.25% (2.58 mg).
283 Likewise, pupal weight was lower in control (1.75 mg) and was increased in pupal weight
284 in CFL treatment at the concentration of 2.5% with 2.39 mg. CFL at the treatment
285 concentration of 1.2%, 5%and 10% also increased the pupal weight with 2.71, 2.33 and 2.20
286 mg respectively. However, all the treatment concentrations were significantly different with
287 control ($F_{4,95}$=9.27; P≤0.05). In contrast, CFL at the treatment concentration of 5% was
288 insignificantly different with 2.5% ($F_{4,95}$=9.27; P> 0.05) and 10% ($F_{4,95}$=9.27; $P > 0.05$).

289 CFL at the treatment concentration of 5% displays highest shell weight of 0.56 mg followed
290 by 0.45mg, 0.44m and 0.37 mg with the treatment concentration of 1.25, 2.5 and 10%
291 respectively. But control showed significantly ($F_{4,95}$=6.401; P≤0.05) lower shell weight of
292 0.33 mg.
293 Similar to shell weight, cocoon shell ratio also exhibited CFL at the concentration of 5%
294 increased the cocoon shell ratio with 19.07% compared to control (16.32%) (Table 2). In
295 contrast, cocoon shell ratio was decreased to 15.75%, 15%, 04% and 14.51% for 2.5%, 10%
296 and 1.25% concentrations respectively. All the treatment concentrations are significantly
297 different with control ($F_{4,95}$=4.72; P≤0.05).
298 As shown in the figure 6, fecundity rate was higher in 5% concentration with 529.2 eggs
299 followed by 2.5% with 487.43%, while, lowest fecundity rate was observed in control
300 (434.23 eggs). CFL at the highest concentration of 10% concentration displays fecundity rate
301 of 457.3 eggs. These results revealed the highest concentration of CFL was not efficient to
302 increase the fecundity rate of eri silkworm. All the CFL treatment concentrations were
303 significantly different (1.25% ($F_{4,9}$=77; P≤0.096), 2.5% ($F_{4,9}$=77; P≤0.001), 5% ($F_{4,9}$=77;
304 P≤0.023) and 10% ($F_{4,9}$=77; P≤0.035)) with control.
305 The adults emerged from the CFL treated concentration showed increase in egg
306 hatchability ratio compared to the control (83.68%). The CFL treated adult exhibit increased
307 egg hatchability rate of 94.32%, 92.85%, 88.17% and 84.16% in the CFL treated
308 concentration of 5%, 10%, 2.5% and 1.25% respectively (Fig. 7). CFL at the treatment
309 concentration of 0.5% and 10% are significantly different with control ($F_{4,9}$=10.91; P≤0.05)
310 except 1.25% ($F_{4,9}$=10.91; P≤0.995) and 2.5% ($F_{4,9}$=10.91; P≤0.671). Additionally, CFL at
311 the treatment concentration of 5% was not significant with 10% concentration ($F_{4,9}$=10.91;
312 P≤0.97).
313 **Amelioration of horticulture crops**

Seedlings of cucumber in control showed germination percentage of 84.36. But germination rate in CFL treated seedlings were significantly higher with 90.18%, 92.02%, 94.3% and 88.05% with the treatment concentrations of 1.25%, 2.5%, 5% and 10% respectively. All the treatment concentrations were significantly different with control ($F_{4,9}$=66.98; P≤0.05). Parallel to cucumber, the seedling percentage of CFL treated radish seedlings significantly influenced the seed germination percentage with 85.02%, 90.08%, 94.02% and 91.03% with the treatment concentration of 1.25%, 2.5%, 5% and 10% respectively (Table 3). In contrast, control seedlings showed lower germination rate of 78.06% and it was significantly different ($F_{4,10}$=27.89; P≤0.05) when compared with other treatment concentrations of fly ash (1.25, 2.5, 5 and 10%).

CFL significantly altered the relative water content of cucumber seedlings. Control seedlings show lower relative water content with 53.48% and it was significantlydifferent ($F_{4,19}$=41.21; P≤0.05) when compared to CFL treated concentration (1.25%, 2.5%, 5% and 10%). In contrast, CFL treated (1.25, 2.5, 5 and 10%) cucumber seedlings showed higher water holding capacity with the range of 72.30%, 84.30%, 86.30%, and 93.4% respectively (Table 3). Similar to cucumber, relative water control of radish also increased with 70.6%, 83.4%, 85.8% and 96% with the CFL respective treatment concentration of 1.25%, 2.5%, 5% and 10%. However, control seedlings showed lower relative water content with 59.04% and displayed significant difference ($F_{4,20}$=23.46; P≤0.05) when compared to CFL treated concentration (1.25%, 2.5%, 5% and 10%). In addition, CFL at the treatment concentration of 2.5% insignificant ($F_{4,20}$=23.46; P≤0.977) with 5% concentration.

Cucumber root-shoot ratio also demonstrated that increasing concentration of CFL increases the root-shoot ratio when compared to control (58.48%) (Table 3). Root-shoot was higher at 10% concentration with 87.66% followed by 5% (80.0%), 2.5% (73.66%) and 1.25% (64.33%). All the treatment concentrations were significantly different ($F_{4,10}$=23.46;

339 $P \leq 0.977$) over control. Moreover, radish seedlings also exhibited higher root to shoot ratio in
340 FLP treatment concentrations. Radish seedlings of control showed lower root to shoot ratio of
341 73.40% and in contrast higher root shoot ratio were observed at 10% (95.12%), 5% (87.8%),
342 2.5% (86.72%) and 1.25% (80%) respectively. Control was significantly different
343 ($F_{4,43}$=13.35; $P \leq 0.05$) with other treatment concentration (1.25%, 2.5%, 5% and 10%)
344 conversely, CFL at 2.5% concentration was not significant with 5% concentration
345 ($F_{4,43}$=13.35; $P \leq 0.930$).

346 CFL treated cucumber seedlings showed an increase in vigour index of 606.33, 683.93,
347 687.50 and 648.67 with the treatment concentration of 1.25%, 2.5%, 5% and 10%
348 respectively. However, control seedlings showed significantly ($F_{4,9}$=2.13; $P \leq 0.05$) lower
349 in vigour index of 585.67. CFL at the treatment concentration of 0.5% was not significantly
350 different with 2.5% ($F_{4,9}$=2.13; $P \leq 0.915$) and 10% ($F_{4,9}$=2.13; $P \leq 0.912$) for cucumber
351 seedlings. Similarly, vigour index of control radish seedling exhibited lower index value of
352 526.67 but CFL treated seedlings showed increase in vigour index of 604.62, 633.73, 758.15
353 and 636.57 with the treatment of 1.25%, 2.5%, 5% and 10% respectively (Table 3). All the
354 treatment concentrations 1.25% ($F_{4,9}$=9.76; $P \leq 0.295$), 2.5% ($F_{4,9}$=9.76; $P \leq 0.099$), 5%
355 ($F_{4,9}$=9.76; $P \leq 0.008$) and 10% ($F_{4,9}$=9.76; $P \leq 0.002$) were significantly different with control
356 cucumber seedlings.

357 **Physico-chemical analysis of soil**

358 The pH of control soil and CFL was very alkaline. In addition, an electric conductivity of
359 control soil was normal 0.34 dS m^{-1} but CFL shows 1.50 dS m^{-1}. In addition, available
360 nitrogen was low in all the treatments with 168 (5%), 165 (Control), 140 (5%) and 48 (1.25)
361 kg/ha. Similar to nitrogen level, organic carbon also lower in all the treatments of control (4.5
362 g/kg), CFL (3 g/kg), 1.25% (3 g/kg) and 5% (4.5 g/kg). Further, available phosphorous was
363 higher in 5% concentration with 42 kg/ha followed by CFL (40 kg/ha), 1.25% (39 kg/ha) and

364 control (38 kg/ha). Additionally, available potassium was higher in CFL and 5%
365 concentration with 561 and 306 kg/ha respectively. But medium potassium level was
366 observed in 1.25% and control with 236 and 141 kg/ha respectively (Table 4).

367 **Discussion**

368 Eri silkworm rearing is considered as a secondary crop and being a meagre source of
369 additional income comparable with profit of mulberry silkworm (Sakthivel & Qudri, 2013) .
370 Eri silkworm culture is a farmhouse activity which guarantees profitable domestic
371 employment with 55% woman contribution [19]. Dietary efficiency of the food plants from
372 which the silkworm derives their nutritional requirement depends upon their chemical present
373 in their feed.

374 Currently, A great deal is known concerning the qualitative nutritional requirement of
375 insect. However, the quantitative aspects of insect nutrition have received less attention and
376 there have been only few studies on the rate of food intake and efficiency of food utilization.
377 Our studies clearly demonstrate that CFL influenced the pupal weight, cocoon shell ratio,
378 fecundity, egg hatchability of the development of silkworm. Fly ash disposal and
379 management are the great challenges to scientist, and now they found some basic mineral
380 nutrients present in CFL, which are necessary for the growth of insects and plants. Our study
381 proved that CFL (1.25%) incorporated leaves have the following minerals which are as
382 follows: Oxygen (20.12%), Magnesium (2.4%), Silica (6.85%), Chlorine (1.38%), Potassium
383 (25.14%), Calcium (11.12%) and Sulphur (1.07%). Our findings also displayed that CFL
384 incorporated castor leaf increased the larval growth of eri silkworm. Similar to our findings,
385 Devaiah *et al*. (1985), reported that the larval, pupal and shell ratio percentage were superior
386 when the larvae were fed with tapioca up to second instar and subsequently on castor.

The pupal weight, cocoon shell ratio and fecundity rate are some of the indicative factor of the growth of the eri silkworm. In the present study it was found that pupal weight, cocoon shell ratio, fecundity, egg hatchability and relative growth rate of larvae increase when treated with CFL incorporated castor leaves. It is was also found that the performance of eri silkworm was better on CFL treated at 5% concentration. From the present study it can be inferred that, rearing of eri silkworm in castor leaf incorporated with 5% CFL is best in terms of larval growth and production of silk. Further studies on parameters on silk fibre will be helpful for confirmation of silk quality. The change in of the soil characteristics could be due to addition of fly ash since their incorporation in soil reduces the bulk density of soil thus helping in better pegging and pod formation and thus increasing the crop yield (Mittra et al., 2005).

Many research studies have reported that fly ash powder increased the yield of crops such as: wheat (*Triticum aestivum*), alfalfa (*Medicago sativa*), barley (*Hordeum vulgare*), bermudagrass (*Cynodon dactylon*), Sabai grass (*Eulaiopsis binata*), mung (*Vigna unguiculata*) and white clover (*Trifolium repens*) (Usmani & Kumar, 2017). Similarly our results also exhibited showed increase in root and shoot growth of cucumber and radish with CFL treated seedlings. Growth parameters such as growth indices, relative growth rate, water holding capacity of a plant which is a measure of efficiency in plants showed variable response when incorporated with fly ash. The present research displays that CFL at 10% concentration increases the seed germination percentage (94.02%), root-shoot ratio (87.66%), relative water content (95.5%) and vigours index (647.67) of cucumber. Similar results were also observed in FLP treated radish seedlings which is in line with other studies as reported earlier (Singh & Agrawal, 2010).

Conclusion

Fly ash particulate liquid (CFL) incorporated leaves showed increase in mineral rate and thus enhances the growth of silkworm. CFL doesn't cause mortality to silkworm, however, CFL enhance the pupal weight, cocoon weight, shell weight, cocoon shell ratio and relative growth rate when compared to control. On the other hand, CFL enhanced the seed germination percentage of cucumber and radish. Moreover, CFL increased the length of root, hypocotyledon, epicotyledon and branches of root. CFL amended soil enhanced the soil properties and thus increased the root shoot ratio, relative water content and vigour's index of both cucumber and radish. The research suggests that CFL has a potential to enhance the seedling production of both cucumber and radish and displayed some significant results. Thus our research has made an attempt to improve the efficient removal of fly ash from environment and minimize the environmental pollution.

Conflict

All authors have no conflict

Contribution of the authors

All authors equally contributed to this manuscript.

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Figures

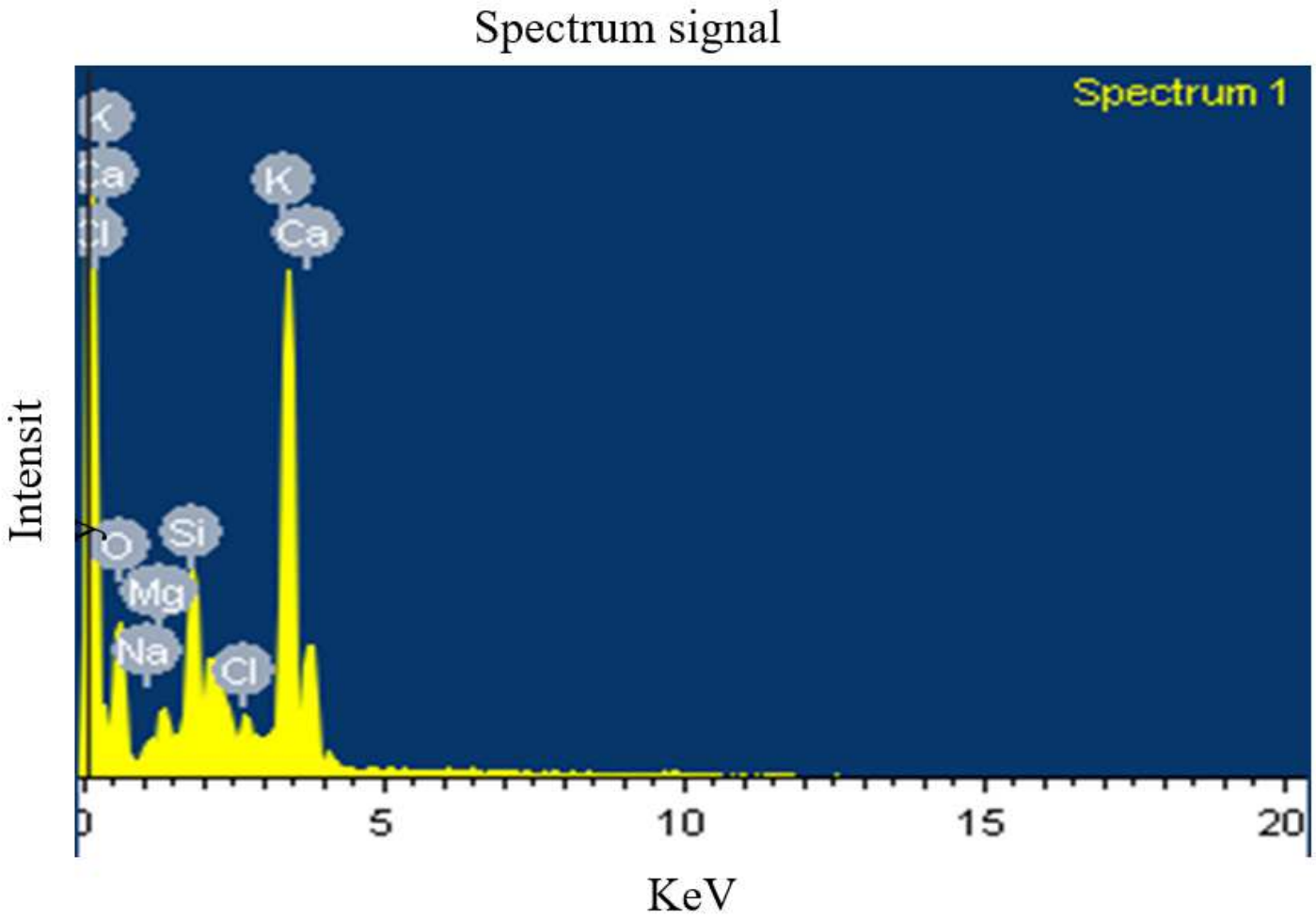

Figure 1

EDAX analysis of control castor leaves.

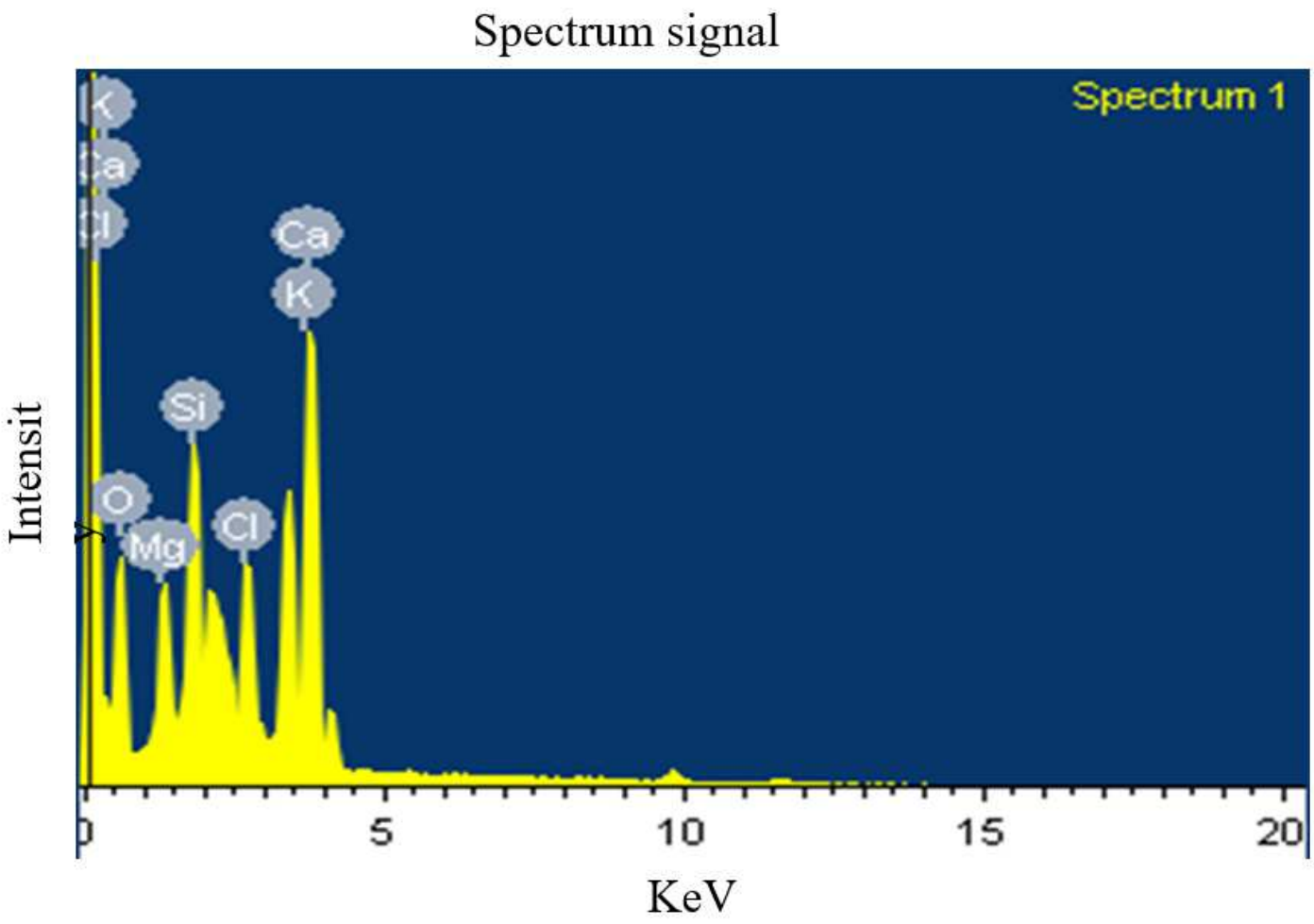

Figure 2

EDAX analysis of castor leaves incorporated at 1.25%.

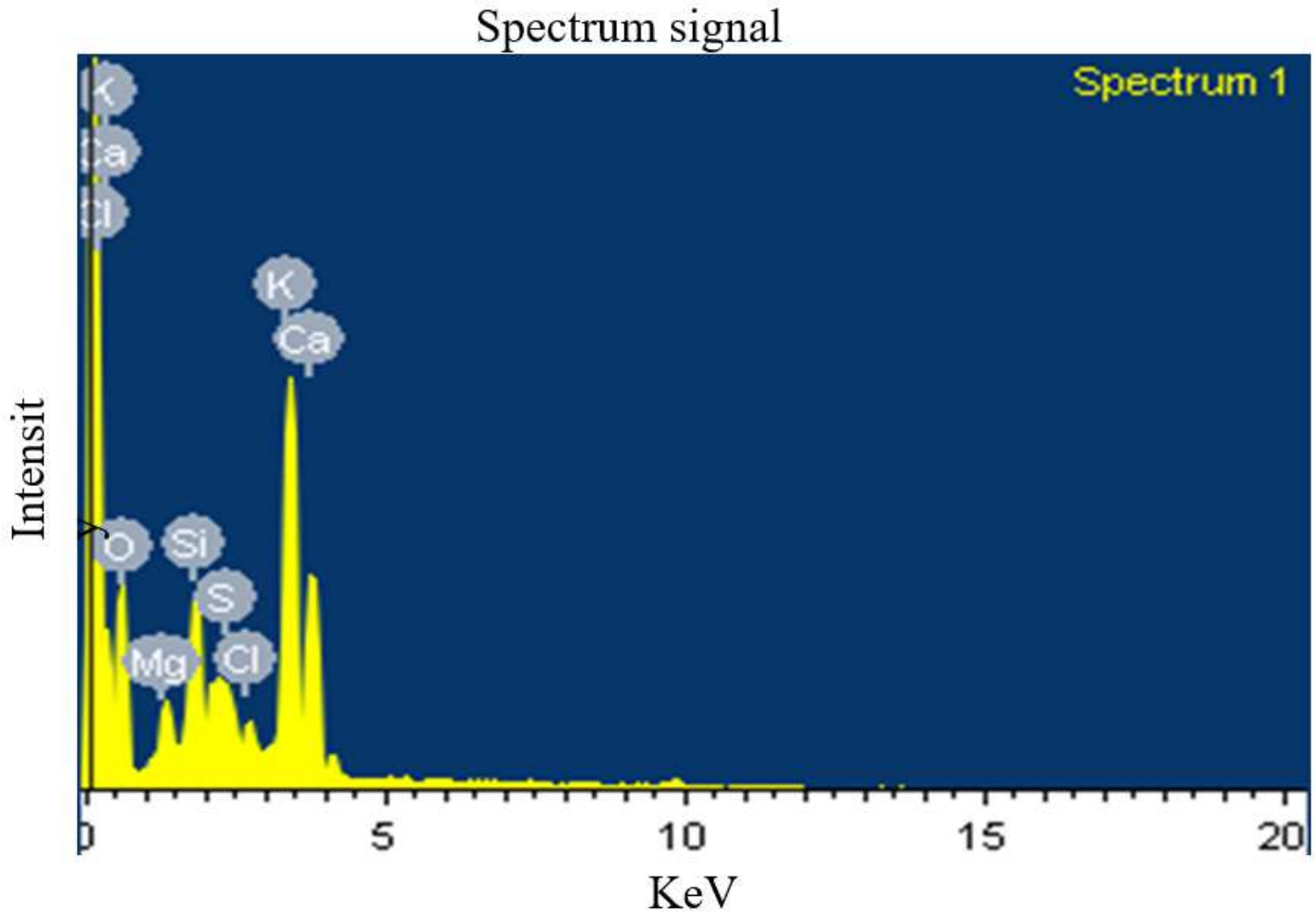

Figure 3

EDAX analysis of castor leaves incorporated at 10%.

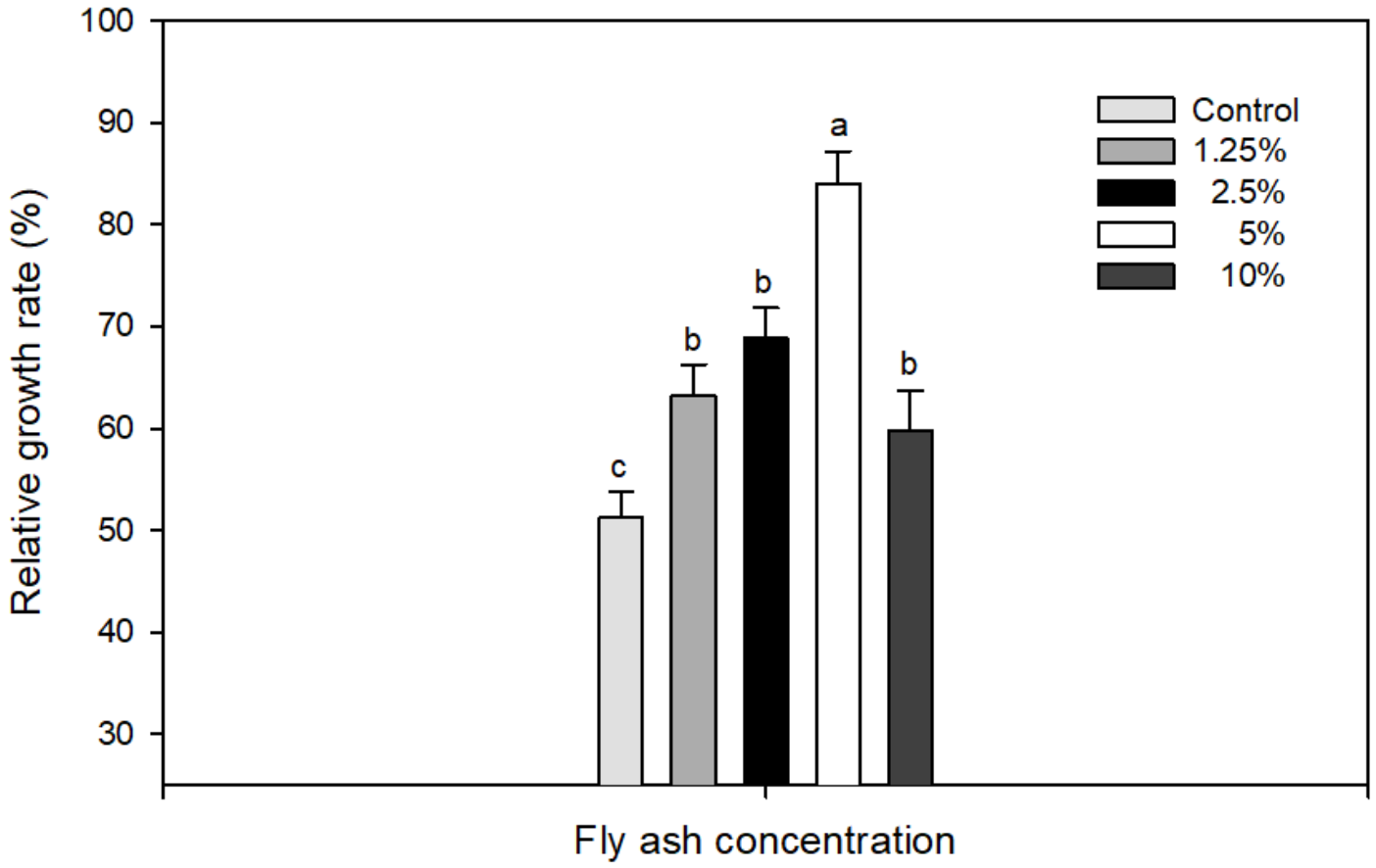

Figure 4

Relative growth rate of eri silkworm after treatment with fly ash solution at various concentrations. Means (±(SE) standard error) followed by the sameletters above bars indicate no significant difference ($P \leq 0.05$) according to a Tukeytest.

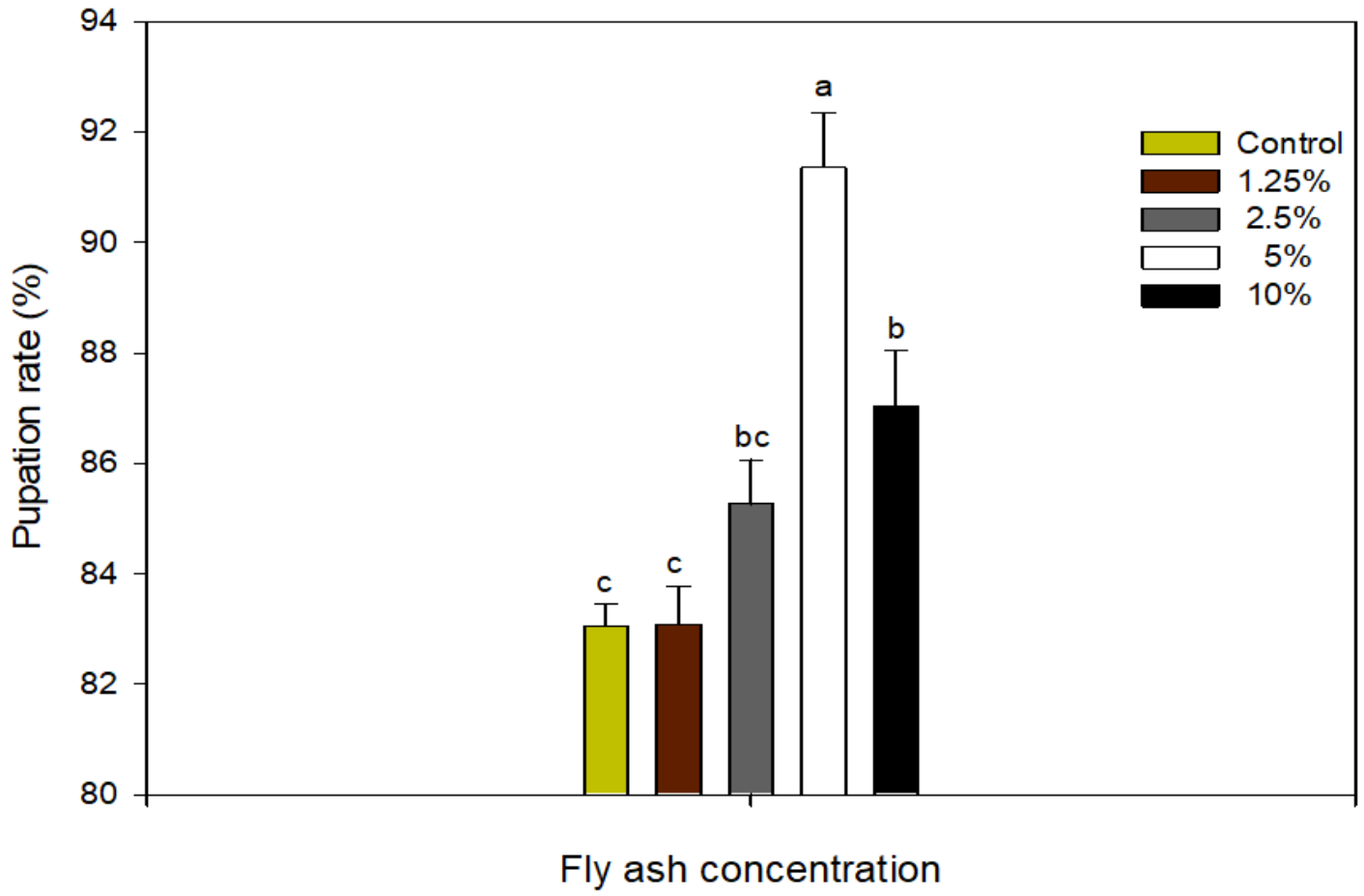

Figure 5

Pupation rate of eri silkworm after treatment with fly ash solution at various concentration. Means (±(SE) standard error) followed by the sameletters above bars indicate no significant difference ($P \leq 0.05$) according to a Tukeytest.

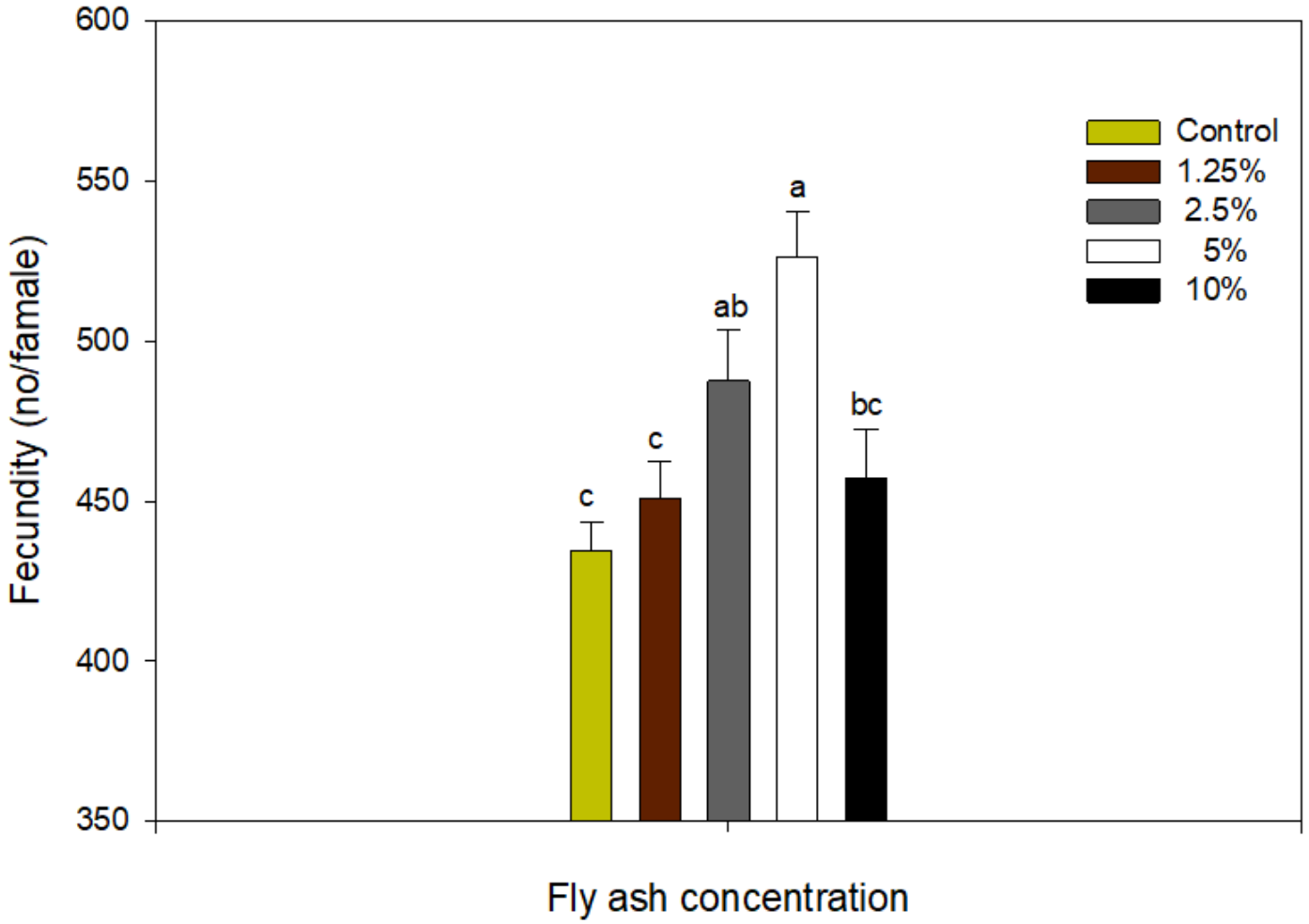

Figure 6

Fecundity (%) of eri silkworm after treatment with fly ash solution at various concentrations. Means (± (SE) standard error) followed by the sameletters above bars indicate no significant difference ($P \leq 0.05$) according to a Tukeytest.

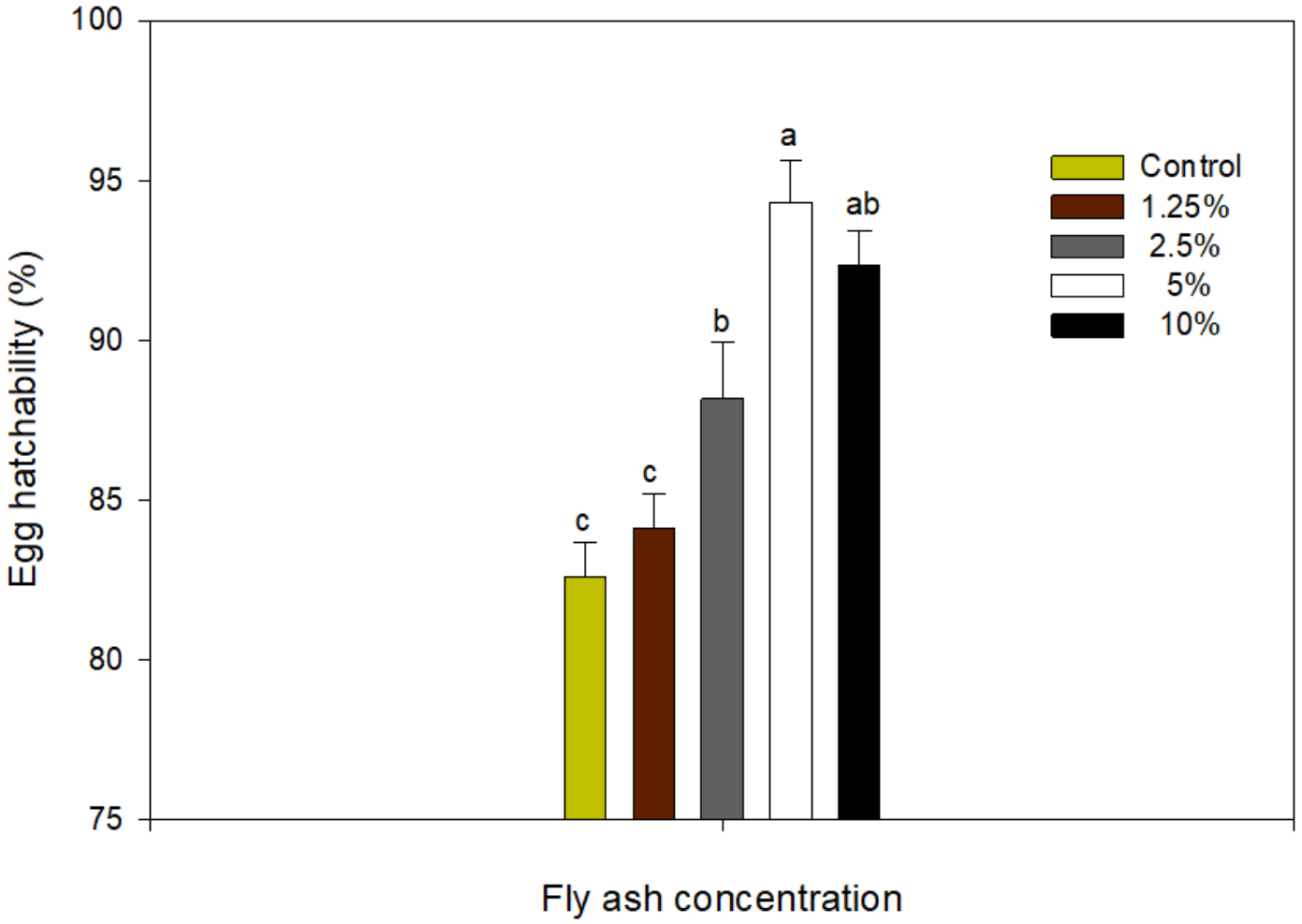

Figure 7

Hatchability (%) of eri silkworm after treatment with fly ash solution at various concentrations. Means (± (SE) standard error) followed by the sameletters above bars indicate no significant difference ($P \leq 0.05$) according to a Tukeytest.