Does the Nanoparticle Improve the Leaf Pigmentation In Rice Grown Under Aluminium Toxic Soil?

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Abstract

Nanoparticles (NP) are one of the nanomaterials that are engineered and are also bioactive with brilliant physiochemical properties. These may be used for the restoration of plants grown at sites of dangerous waste, both morphologically and physiologically. In this paper, we want to know one frequent question that, do the nanoparticles improve the leaf pigmentation in rice grown under aluminum toxic soil. We will target the chlorophyll pigments in the leaves of the rice. It was found that the average chlorophyll a was significantly enhanced by about 36.66% with respect to T1 when treated with Fibroin NPs upon Aluminium stress whereas only sole Fibroin NPs were applied (T6). KNO_3 Nanoparticles when applied upon Aluminium stress (T6). In comparison with control (T0) with 90 DAT of interval, it is obvious that the average chlorophyl "b" has decreased significantly by 41.97 percent exposed to heavy metal stress (T1). Exogenous application of KNO_3 particles on the leaves (T3) enhanced the chlorophyll “b” by 7.07% as compared to (T1) at 90 DAT.

Keywords: Agriculture, Biotic, Crop, Dose, Economy, Forage, Silk, Protein

Introduction

Agricultural diagnosis, agricultural manipulation, drug supply, drug supplies, nano-bio-sensors, nano-pesticides, nano herbicides and controlled releases of nano-fertilizers and nano-complexes are all the roles of nanotechnology in agricultural research [1, 2, 3, 4 and 5]. To cope with Aluminium toxicity plants have developed certain adaptive mechanisms to survive in even toxic conditions which are as follows. (1) Exclusion or Resistance to Aluminium to exclude the entry of metal into the cell by secreting certain Organic acids or phenolic compounds which further bind Al^{+3} and prevents its uptake into the cytosol. (2) Exhibiting Internal tolerance by compartmentalizing Al in vacuoles, the formation of Al complexes with organic substances in the cytosol and improved scavenging via ROS, to avoid toxicity [6, 7, 8, 9, 10 and 11]. Ample of detoxification methodologies have been adopted by the plants in order to fight back with the metal toxicity and their accumulation such as a cellular antioxidant system that constitutes Superoxide dismutase (SOD), Ascorbate peroxidase(APX), Glutathione reductase (GR) and Catalase (CAT). They help in the detoxification of oxyradical which further inhibits the oxidation of biomolecules [12, 13, 14, 15, 16 and 17].

Many plant species have developed certain plant species for the alleviation of Al internally and/or externally such as secretion of various organic acids anions (citrate, malate, and oxalate) from roots which further chelate Al ions in the rhizosphere [18,19, 20, 21, 22, 23 and 24]. Furthermore, a number of Al tolerance genes have been explored in plants especially rice [25, 26, 27, 28, 29 and 30]. It was found that NH^+_4 ions reduced aluminum accumulations in the roots by altering the cell wall properties which took place due to a decrease in ph by the NH4 uptake [31, 32, 33, 34 and 35]. Al-induced Oxidative stress leads to the splitting of membrane integrity and stability [36, 37, 38, 39, and 40]. Plants such as Vignita radiate (green gram), Oryza sativa (rice) and Lolium penne (ryegrass)[41, 42, 43, 44, 45, 46 and 47] exhibited enhanced Lipid peroxidation onto Al exposure. Even Brassia juices genotypes verified enhanced oxidative stress upon Al exposure. Al enhanced the content of (ASA), Ascorbate, dehydroascorbate (DHA) and total Ascorbate (ASA+DHA) in B.juncea species. [48, 49, 50, 51 and 52].When plants are brought under Al exposure they are seen to be involved in free radical scavenging activities such as DPPH and HRSA in two genotypes of mustard [31, 36, 38, 39 and 50]. The same findings were shown by (Chutipaijit 2016) which exaggerates on better the DPPH activity, more shall the rice genotypes be adaptive to osmotic stress based on antioxidant activities. Aluminum at very low concentration induces growth in native crops which have developed adaptive mechanisms [23, 24, 26, 27, and 29]. Low level of Al-induced root biomass synthesis in Tabebuia chrysantha tree, whereas the effect was opposite when high levels of exposure were made [30, 34, 37, 39, 41, 45, and 47]. An increased root growth Al can induce or even have no effect on the essential nutrient uptake especially in hyperaccumulator crops [23, 27, 28 and 29]. Al induces alkaline Phosphatase activity and organic phosphorus activity in the marine diatom *Thalassiosira weissflogii* [30, 31, 32, and 33] Aluminium induces color changes in some hyperaccumulator plants.

Methodology

The experiment was conducted at Natural Ventilated Poly house, School of Agriculture, Lovely Professional University (LPU), Phagwara, Punjab. The farm situated at attitude 232 meters above sea level, latitude 31.244604 N and longitude 75.701022 E as per Google map (Figure 1).

Figure 1. Google map of the experimental site

(Source: Google Earth, 2019)

CLIMATE CONDITION

Punjab Trans-Gangetic Plains Region Phagwara falls in the Central Plain Zone of Punjab. Generally, in June the hottest month of the year with a maximum temperature of 45°C and a minimum of 27°C, the annual average temperature is 24°C. In January during winters the temperature falls down up to 4 to 6°C. Monsoon starts in the last of June / early of July having a normal annual rainfall of 686mm.

TREATMENTS DETAILS

The pot experiment was conducted on the farm of the School of Agriculture, Lovely Professional University, Jalandhar Punjab with one genotype Pusa Basmati 1121 of Rice. Genotype took from Punjab Agriculture University, Punjab. The pot size for the experiment will be diameter: 30 cm and height 25 cm. Heavy metal stress was created by foliar application of aluminium (100ppm) at the flowering stage. KNO_3 protein nanoparticle (1%) and Fibroin Nanoparticle (1%) were applied through a foliar application at the flowering stage. The various measurements were taken at 90 DAT (Table 1 and 2).

Table 1: Treatments Detail

Treatments	Details of the treatments
T-0	Control
T-1	Al (100ppm)
T-2	Fibroin nanoparticle (1%)
T-3	KNO_3 protein nanoparticle (1%)
T-4	Al (100ppm) + Fibroin nanoparticle (1%)
T-5	Al (100ppm) + KNO_3 protein nanoparticle (1%)
T-6	Al (100ppm) + KNO_3 protein nanoparticle (1%) + Fibroin Nanoparticle (1%)

Table 2: Layout Details

S. No.	Particulars	Details

1.	Layout	CRD
2.	Treatment	7
3.	Replications	3
4.	Total Number of pots	7*3=21
5.	Soil per pot	7 kg
6.	Genotype	Pusa Basmati 1121

OBSERVATION TO BE RECORDED

The observations were recorded at 90 DAT. The recorded observations of biochemical and the standard procedure adopted during the course of study are given below:

BIOCHEMICAL PARAMETERS

Chlorophyll content (mg g^{-1} fresh weight)

The chlorophyll content in the leaf of Rice was estimated by the method of Arnon DI. (1949).

RESULTS and DISCUSSION

Chlorophyll “a” content (mg g^{-1} fresh weight)

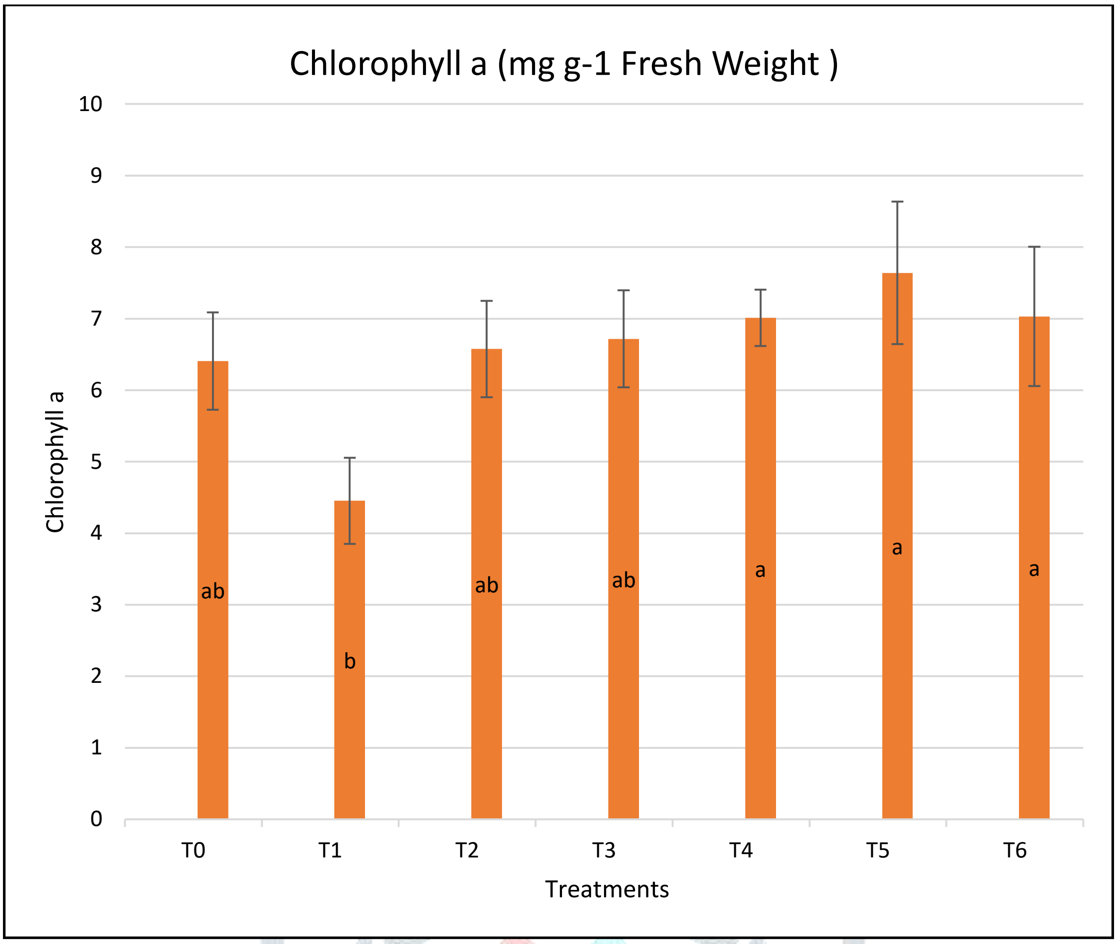
Effect of Silk Fibroin Nanoparticle (NP) and Potassium Nitrate (KNO_3) and their combination on chlorophyll “a” was studied in rice variety Pusa Basmati 1121 under the Aluminium toxicity stress. Data were recorded at 90 days after transplanting (DAT) (Table 3 and Fig. 2). It is apparent that the mean "a" of chlorophyll decreased considerably by 30.5%, compared to control (T0), at 90 DAT interval when exposed to heavy metal stress (T1). Exogenous application of KNO_3 particles on the leaves (T3) enhanced the chlorophyll “a” by 33.71% as compared to (T1) at 90 DAT. In comparison to T1, the exogenous application of Fibroin Nanoparticle (T2) showed enhancement in the chlorophyll “a” by 32.27%, on proposed DAT. The treatments T4, when compared with T1, showed that Fibroin NPs enhanced the chlorophyll a by only 36.49% whereas KNO_3 NPS in T5 enhanced the same by 41.70% when applied along with Aluminium stress. The average chlorophyll a was significantly enhanced by about 36.66% with respect to T1 when treated with Fibroin NPs upon Aluminium stress whereas only sole Fibroin NPs were applied (T6). KNO_3 Nanoparticles when applied upon Aluminium stress (T6). Malta *et al*. (2016) discussed the soil fertility and its relation with the plant nutrients in the species Rudgea viburnoides which is a natural Al hyperaccumulator [52]. It was found that soil having low fertility still grew plants possessing enriched nutrients especially during the vegetative stage and even assembled a lot of Al (more than 10g Al kg^{-1}) on leaves. Al was seen deposited primarily on the cell walls (pectin) and secondarily on the chloroplasts and suberized cell wall. Moreno-Alvarado *et al.* (2017) discussed the effect of 200µM Al on the growth of four cultivars of rice crops. It was found that Al exposed plants indicated 30% more growth as compared with the control treatment, and also showed a significant increase of 140% in root dry biomass [53]. Sugar concentration was found to increase tenfold in Al-treated plants as compared to the control treatment. Cooperative enhancement of P and K in the roots and Mg in the shoots were visible in the Al-treated plants.

Table 3. Chlorophyll “a” in rice leaf during *Kharif*

Treatments	Chlorophyll “a” in rice leaf at 90 DAT
T0	$6.40732^{ab} \pm 0.682093$
T1	$4.453^{b} \pm 0.602225$
T2	$6.5753^{ab} \pm 0.672825$
T3	$6.71766^{ab} \pm 0.67924$
T4	$7.01185^{a} \pm 0.392937$
T5	$7.63855^{a} \pm 0.996401$
T6	$7.03061^{a} \pm 0.972508$

where, Data are in the form mean± SEM. Significance at $P \leq 0.05$ using SPSS ver. 22. T0= Control; T1: Aluminium chloride (100ppm); T2: Fibroin nanoparticle (1%); T3: KNO_3 nanoparticle (1%); T4: Aluminium chloride (100ppm) + Fibroin nanoparticle (1%); T5: Aluminium chloride (100ppm) + KNO_3 Nanoparticle (1%); T6: Aluminium chloride (100ppm) + Fibroin nanoparticle (1%) + KNO_3 Nanoparticle (1%).

Figure 2. Chlorophyll “a” in rice leaf during *Kharif*



where, Data are in the form mean± SEM. Significance at P≤0.05 using SPSS ver. 22. T0= Control; T1: Aluminium chloride (100ppm); T2: Fibroin nanoparticle (1%); T3: KNO_3 nanoparticle (1%); T4: Aluminium chloride (100ppm) + Fibroin nanoparticle (1%); T5: Aluminium chloride (100ppm) + KNO_3 Nanoparticle (1%); T6: Aluminium chloride (100ppm) + Fibroin nanoparticle (1%) + KNO_3 Nanoparticle (1%).

Chlorophyll "b" content (mg g^{-1} fresh weight)

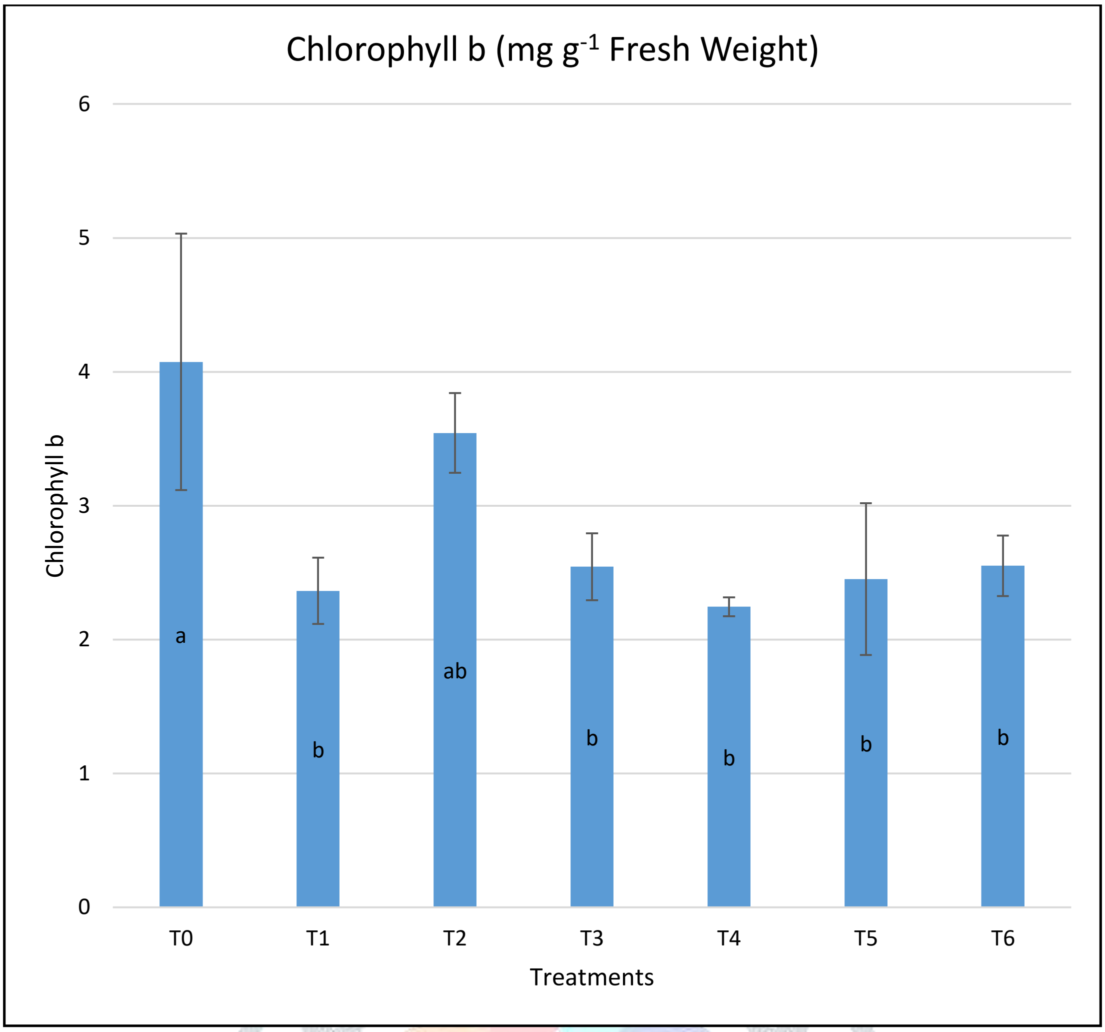
Effect of Silk Fibroin Nanoparticle (NP) and Potassium Nitrate (KNO_3) and their combination on chlorophyll "b" was studied in rice variety Pusa Basmati 1121 under the Aluminium toxicity stress. Data were recorded at 90 days after transplanting (DAT) (Table 4 and Fig. 3). In the event of exposure to heavy metal strain (T1), on average "b" was decreased significantly by 41.97% compared to 90 DAT in a control interval (T0). It is obvious. Exogenous application of KNO_3 particles on the leaves (T3) enhanced the chlorophyll "b" by 7.07% as compared to (T1) at 90 DAT. In comparison to T1, the exogenous application of Fibroin Nanoparticle (T2) showed enhancement in the chlorophyll "b" by 33.27%, on proposed DAT. The treatments T4, when compared with T1, showed that Fibroin NPs reduced the chlorophyll b by only 5.04% whereas KNO_3 NPS in T5 enhanced the same by 3.58% when applied along with Aluminium stress. The average chlorophyll index was significantly enhanced by about 7.33% with respect to T1 when treated with Fibroin NPs upon Aluminium stress whereas only sole Fibroin NPs were applied (T6). KNO_3 Nanoparticles when applied upon Aluminium stress (T6). Malta *et al.* (2016) discussed the soil fertility and its relation with the plant nutrients in the species Rudgea viburnoides which is a natural Al hyperaccumulator. It was found that soil having low fertility still grew plants possessing enriched nutrients especially during the vegetative stage and even assembled a lot of Al (more than 10g Al kg^{-1}) on leaves [52]. Al was seen deposited primarily on the cell walls (pectin) and secondarily on the chloroplasts and suberized cell wall. Moreno-Alvarado *et al.* (2017) discussed the effect of 200µM Al on the growth of four cultivars of rice crops. It was found that Al exposed plants indicated 30% more growth as compared with the control treatment, and also showed a significant increase of 140% in root dry biomass. Sugar concentration was found to increase tenfold in Al-treated plants as compared to the control treatment. Cooperative enhancement of P and K in the roots and Mg in the shoots were visible in the Al-treated plants [53].

Table 4. Chlorophyll “b” in rice leaf during *Kharif*

Treatments	Chlorophyll “b” in rice leaf at 90 DAT
T0	$4.0743^{a} \pm 0.95732$
T1	$2.364^{b} \pm 0.24693$
T2	$3.5427^{ab} \pm 0.29806$
T3	$2.544^{b} \pm 0.24931$
T4	$2.2447^{b} \pm 0.06958$
T5	$2.452^{b} \pm 0.56705$
T6	$2.551^{b} \pm 0.2255$

where, Data are in the form mean± SEM. Significance at P≤0.05 using SPSS ver. 22. T0= Control; T1: Aluminium chloride (100ppm); T2: Fibroin nanoparticle (1%); T3: KNO_3 nanoparticle (1%); T4: Aluminium chloride (100ppm) + Fibroin nanoparticle (1%); T5: Aluminium chloride (100ppm) + KNO_3 Nanoparticle (1%); T6: Aluminium chloride (100ppm) + Fibroin nanoparticle (1%) + KNO_3 Nanoparticle (1%).

Figure 3. Chlorophyll “b” in rice leaf during *Kharif*



where, Data are in the form mean± SEM. Significance at P≤0.05 using SPSS ver. 22. T0= Control; T1: Aluminium chloride (100ppm); T2: Fibroin nanoparticle (1%); T3: KNO_3 nanoparticle (1%); T4: Aluminium chloride (100ppm) + Fibroin nanoparticle (1%); T5: Aluminium chloride (100ppm) + KNO_3 Nanoparticle (1%); T6: Aluminium chloride (100ppm) + Fibroin nanoparticle (1%) + KNO_3 Nanoparticle (1%).

Conclusion

Depending on cultivar, treatment and various growth conditions, the effects of Nanoparticles were both positive and negative. Nano fertilizers clearly have certain specific characteristics, such as improved production, ultra high absorption, improved photosynthesis, and increasing floor surface area. Based on the above study it is clear that, the influence of metal and metal oxide nanoparticles on various crops at several diagnostic levels. Magnetic nanoparticle exposure, on the other hand, showed positive results in case of growth and also ensured that plant operates mechanisms to protect itself from oxidation stress.

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Author Contributions

The study was designed by P.K. and Purnima, the biochemical protocolizations were established, experiments were carried out and the data analyzed and interpreted were collected. The paper has been written by P.K.

Conflict of Interest Statement

The authors state that they have no interest conflict.

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