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# MITIGATION OF SALINITY STRESS AND *ALTERNARIA* LEAF SPOT DISEASE IN FABA BEAN BY NICOTINAMIDE

**Kamar M. Abd El-Hai[1], Abeer Abdulkhalek Ghoniem[2], Ayman Y. El-Khateeb[3] and Ayman EL-Ghamry[4]**

[1]Department of Leguminous and Forage Crop Diseases, Plant Pathology Research Institute, Agricultural Research Center, Giza, Egypt

[2]Department of Microbiology, Soils, Water andEnvironment Research Institute, Agricultural Research Center, Giza, Egypt

[3]Department of Agricultural Chemistry, Faculty of Agriculture, Mansoura University, Mansoura, Egypt

[4]Department of soil, Faculty of Agriculture, Mansoura University, Egypt

## Abstract

*Vicia faba* is one of the most important leguminous crops, where it represents a major constituent of daily food for most of populations. The present investigation aimed to study the influence of salinity stress and *Alternaria* leaf spot on faba bean cultivars during thresholds of nicotinamide and fungicide Tridex-80.Obtained data pointed out that both of nicotinamide and Tridex-80 had inhibitory effect against *Alternaria* leaf spot pathogen *in vitro*. The germination percentage decreased significantly with increasing soil salinity. However, increasing percentage of germination was associated with nicotinamide and Tridex-80%.Interestingly, low threshold of nicotinamide (200mg/l) was superior to another one, where affected on plant growth parameters. Both of disease incidence and severity of *Alternaria* leaf spot in faba bean were significantly decreased in the presence of thresholds of nicotinamide and Tridex-80. Likewise, increasing of chlorophyll a, b, polysaccharides, free amino acids, proline and antioxidant enzymes as response to nicotinamide thresholds. Ultimately, the yield productivity was consequently increased as the nicotinamide and Tridex-80 doses against salinity stress and *Alternaria* leaf spot disease.

***Key words:*** Faba bean, *Alternaria alternata*, nicotinamide, salinity stress, Antioxidant enzymes.

## Introduction

Soil salinity is the major environmental constraints, which limiting crop production worldwide (FAO, 2008). Salinity stress usually associated with growth reduction, especially in susceptible crop plants. The decline in shoot growth as a result of salt-affected soils is due to inhibition of cell division and cell elongation caused by osmotic effects, ion toxicity and mineral disturbances in plants (Tester and Davenport, 2003). Salt tolerance was differed according to plant genotype, developmental stage, climatic conditions and soil fertility. Seed germination is a critical stage, which limiting the plant growth under saline conditions because seed usually reside near the soil surface, where the salt levels are high (EL-Bastawisy *et al*., 2018). Salt response during germination can be taken as quick indicator for salt tolerance of the plant. Commonly, the assessment of plant response to salinity is based on two parameters: the threshold and the critical salinity levels. Faba bean (*V. faba* L.) is consumable leguminous crop, acting as the fourth primary dietary legume worldwide (Graham and Vance, 2003). Leguminous crops were the second crops to cereals in their importance to human. They account for 27% of the world's primary crop production, with contributing 30-60% of the dietary protein needs of humans (Vance, 2000). Moreover, the dietary importance of legume seeds is expected to grow in accordance with insight of economic and healthy foods., especially to face increasing of human population. In Egypt, *V. faba* is the one of the most important leguminous crops, where it represents a major constituent of daily food for most of populations.

As well as, Faba bean seeds are cultivated in the world due to their richness in protein and vitamins content. They also rich in carbohydrates, fibers and minerals, so they are used in human food and animal feed (Sahile *et al*., 2011). Additionally, fabaceous plants are responsible for biological nitrogen fixation and consequently providing nitrogen source to cropping systems (Boubekeur *et al*., 2012). On the other hand, fabaceous plants, i.e. *Vicia faba* was found to be sensitive or moderate tolerant to salinity stress (Lana *et al*., 2014), where in Egypt, approximately 33% of the cultivated land is already salinized (Abd EL-Hai and EL-Saidy, 2016). Furthermore, *Vicia faba* is suffering from many destructive fungal diseases, e.g. fungal leaf spot that caused by *Alternaria alternata*, which causing serious damage to plant vegetative growth and, consequently decreasing the yield production (Juroszek and Vontiedemann, 2011; Magda *et al*., 2014). The symptoms on the leaves are small, brown irregular-shaped lesions develop into large, gray-brown oval

lesions with concentric rings. Leaf lesions do not always cross over major leaf veins. in such cases lesions may be angular in shape. When several lesions coalesce, a large portion of leaf area becomes necrotic. Inducing resistance against biotic and a biotic stress is a promising modern approach due to the hazards of artificial chemicals on public health and environmental balance. Nicotinamide is a part of the vitamin B group that a water- soluble vitamins. It is also known as nicotinamide and nicotinic acid amide, which has a well- characterized constituent of the pyridine dinucleotide coenzymes NADH and NADPH. These coenzymes are involved in many enzymatic oxidations-reductions reactions in living cells (Abdelhamid *et al*., 2013). They added that, nicotinamide is considered as a stress- associated compound that induces and regulates secondary metabolic accumulation and/or the manifestation of defense metabolism in plant. Maintain of the normal growth and proper development of all organisms are requires the trace amount from vitamins, where acting as coenzymes and thus take essential part in the regulation of metabolism. It is can be limiting factors in the development of plant (Bassouny *et al*., 2008). The present investigation was carried out to study the role of nicotinamide as inducing agent against salinity and fungal leaf spot disease of faba bean ,as well as follow up their extended impact to germination, vegetation and yield of *vicia faba* .

## Materials and Methods

### Faba Bean Seeds and Nicotinamide

Seeds of faba bean cvs.Maser1 and Giza843 were purchased from Legumes Department, Field Crops Research Institute, Agricultural Research Center, Giza, Egypt. Nicotinamide (niacinamide) was obtained from Al-Gomhoria Company, Egypt. Moreover, the chemical fungicide Tridex-80%wp (Mancozeb group) was used in this investigation.

### Pathogen isolation

The pathogenic fungus (*Alternaria alternata*) was isolated from naturally infected leaflets of *Vicia faba*, showing leaf spot symptoms, growing in Dakhlia Governorate, Egypt. It was identified on the basis of cultural and microscopic morphological characters according to Barnett and Hunter(1987). Effect of nicotinamide and Tridex-80% on fungus growth

Nicotinamide at 100, 200, 300 and 400 mg/l, as well as Tridex-80% at 1.5, 2.5 and 3.5 g/l were tested in vitro on linear growth of *Alternaria alternata*. The different concentrations of both tested materials were added to 10ml.of sterilized PDA before solidification, then poured in a sterile petri-dishes. The plates-after solidification, were inoculated with fungal disc (5mm) in the plate center and inoculated at 20 ºC. Three plates were prepared to serve as control by inoculated with the fungus only without any treatment, also three plates for each treatment were used as replicates. The diameter of fungal growth was recorded when particular control filled of petri-dishes with mycelia growth

*The reduction% was measured (after10 days)˚according to the following formula: Reduction%=C-TX100/C, Where C= The growth of A. alternata in check and, T=the growth of A. alternata in each treatment*

The treatments which showed to be more efficient were selected and applied in field experiment

### Field Experiments

Two field experiments were carried out at Tag EL-Ezz, Agric. Res. Station, Dakhlia, Egypt, during 2016/2017 and 2017/2018 seasons. Due to the differentiation in soil salinity, the farm soil was divided into three blocks by measuring EC (3.5, 4.5 and 5.5 $dsm^{-1}$, approximately). A split plot design with three replicates were used in these experiments. The main plots were occupied by salinity levels, sub-plots were occupied by cultivars while sub-sub plots were occupied by treatments. Seeds of faba bean cvs. Maser1 and Giza843 were soaked for 8hrs in nicotinamide at 200 and 400 mg/l and fungicide Tridex-80% at 2.5g/l, before sowing. Treated seeds were sown at the rate of 300 seeds/sub-sub plot in 21 and 13 November in the first season and second one, respectively. The previous treatment was also used as a foliar spraying at 35, 50 and 65 days from sowing.

### Germination and Plant Growth Characters

The percentage of germination was recorded after 15 days from sowing. While, growth parameters per plant-1(height, branches and leaflets number, shoot fresh weight, shoot dry weight and leaf area) were measured after 80 days from sowing. The disk method was used to determine leaf area

### Disease Assessment

After 80 days from sowing (15 days after end spray treatments), plants were investigated for both disease severity and disease incidence of *Alternaria* leaf spot as follow:

The disease severity was determined using the scale from 0-4 according to Vakalunkis (1990)based on the leaf area infected: hence

0 = No leaf lesions
1 = 25% or less
2 = 26 to 50%
3 = 51 to 75%
4 = 76 to 100% in infected leaf area

Then, disease severity%= €NPC×CR/NIP×MSC×100

Where:

NPC=NO. of plants in each class rate, CR=class rate

NIP=NO. of infected plants and MSC=Maximum severity

While, the disease incidence was determined as the percentage of infected leaves

**Physiological Activities**

After 80 days from sowing in the second season only, the physiological activities were determined as follow:

- Photosynthetic pigments (Chl. a, b and Carotenoids) in the third leaf from tip determined according to Lichtenthaler and Buschmann (2001). Pigments were extracted from fresh leaflets by acetone 80%, then measured spectrophotometerically at 662, 645 and 470 nm. The values of chl. a,b and carotenoids were expressed in mg/g fresh weight.
- The total phenolics compound were determined in the fresh shoots according to Malik and Singh (1980)
- Proline content was determined in dry shoots according to the method of Magne and Larher (1992).
- Total soluble sugars (TSS) were extracted by ethanol 80%and determined in dry tissues according to Homme *et al*. (1992).
- Polysaccharides percentage and total carbohydrates% were determined in dry shoots according to the method of Herbert *et al*. (1971).
- Free amino acids were determined by ninhydrin reagent method according to Yemm and Cocking (1955)

**Enzymes Activity**

Extraction of enzymes were done according to Tuzun *et al*. (1989). Peroxidase activity was assayed according to Bergmeyer (1974). The activity of polyphenol oxidase was assayed according to the method of Kar and Mishra (1976), after that, the enzymes activity were calculated according to Kong *et al*. (1999).

**Yield Components**

At harvest time, samples were taken to estimate pods number plant-1, plant seed yield and 100-seed weight (g)

**Statistical Analysis**

Data subjected to analysis of variance for a split-split plot design. Means were separated according to probability value of ≤0.05.All the statistical analysis were performed by software packages Co Stat (version 6.4, CoHort Software, USA)

## Results

Linear growth of *Alternaria* leaf spot as thresholds of Tridex-80% and Nicotinamide

Data as showed in Fig 1 revealed that, all tested concentrations of both Tridex-80% (1.5, 2.5 and 3.5 g/l) and nicotinamide (100, 200, 300 and 400 mg/l) have antifungal activities and decrease the linear growth of *Alternaria alternata*. Tridex-80% at doses of 2.5 and 3.5 g/l, as well as nicotinamide at 400mg/l led to completely inhibition of fungal pathogen. Nicotinamide at 100mg/l was the least one, which gave 36.33% growth reduction of the pathogen. There is no significant difference between the other two concentrations of nicotinamide (200 and 300mg/l). Wherein, both of Tridex-80% at 2.5g/l and nicotinamide with levels of 200 and 400 mg/l were selected for further studies in the field experiments due to their activity against fungal pathogen, as well as salinity stress

**Field Experiments:**

**Germination Percentage**

The interactive effects of salinity stress and nicotinamide on germination percentage of both faba bean cultivars (Maser1 and Giza 843) are presented in table (1). Data showed that *Vicia faba* var. Giza 843 was the most salt-tolerant cultivar, where germination percentage significantly increased compared with Maser1 under different levels of salinity in both seasons. It can be noticed that, the germination percentage decreased significantly with increasing the soil salinity levels over all nicotinamide used. The highest reduction in these parameters occurred under high soil salinity level (5.5Mm). Regarding the effects of Tridex-80% and nicotinamide, data also showed that, all tested agents increased the germination percentage. The fungicide was more effective followed by the low level of nicotinamide (200mg/l). Concerning the interaction between salinity and treatments, data revealed that, both levels of nicotinamide and Tridex-80% decreased the negative effects of salinity on faba bean seed germination%

**Plant Growth Characters**

The effects of nicotinamide on plant heights (Cm), branches and leaflets number plant-1, shoot f.w, shoot D.w and leaf area of both faba bean cultivars grown under three levels of soil salinity are presented in tables

(2,3). There are significant gradual reductions in growth parameters with increasing salinity level. Maser1 cultivar gave the lowest values compared with Giza 843. Nicotinamide at both levels increased significantly plant growth characters and alleviated the harmful effects of salinity. The low-level 200 mg/l was more effective. While, Tridex-80% had no significant effect on plant heights, branches number and leaflets number but increased shoot fresh weight, shoot dry weight and leaf area

**Disease Assessment**

Disease assessment was estimated as disease severity and disease incidence (infection %) at 80 days after sowing. Data as shown in table (4), represent the influence of the fungicide Tridex-80% and nicotinamide on both disease severity and incidence of Alternaria leaf spot of faba bean growing for two seasons under salinity stress. Maser1 cultivar was the most susceptible for infected with *Alternaria alternata*. Increasing salinity level caused significant increases in disease severity and incidence, the maximum values occurred under the highest level (5.50 mM). Seed treatments followed by foliar spraying of both fungicide and nicotinamide decreased significantly disease assessment measures (severity and incidence) under various levels of salinity. In this respect, Tridex-80% was more effective followed by the low level of nicotinamide (200mg/l)

**Physiological Activities**

**Photosynthetic Pigments**

Data as shown in table (5), clearly revealed that, chlorophyll a and chlorophyll b were decreased significantly with increasing soil salinity levels from 3.5 Mm to 5.5 Mm. However, a beneficial effect of salinity was recorded in carotenoids, which recorded an induction response with increasing salinity levels. Giza 843 was the best cultivar in chlorophyll a and chlorophyll b, while Maser1 was the best in carotenoids. The external applications of both concentrations of nicotinamide increased significantly all photosynthetic pigments concentrations under soil salinity conditions. The maximum increase was recorded with 200 mg/l nicotinamide.

Total Phenol, Proline and Total Soluble Sugars

It was investigated that (Table 6), faba bean Giza843 cultivar recorded the highest values of total phenol, proline and total soluble sugars contents. Significant gradual induction in these parameters were observed with gradual increase in soil salinity levels. The addition of the fungicide and nicotinamide treatments were effective in phenols, proline and total soluble sugars content of faba bean shoots under different levels of salinity. The low level of nicotinamide was superior to others, while the fungicide came late

Polysaccharides, total carbohydrates and free amino acids

The effect of nicotinamide on the content of faba bean shoots of polysaccharides, total carbohydrates and free amino acids under saline soil are presented in table (7). It could be noticed that, there are a negative correlation between salinity levels and the accumulation of polysaccharides and total carbohydrates in faba bean shoots. While, free amino acids increased significantly with increasing salinity levels. Moreover, the application of nicotinamide at both concentrations increased significantly the above parameters compared with the untreated control and corresponding salinity levels. The low level of nicotinamide was more effective. Meanwhile, polysaccharides and total carbohydrates in faba bean shoots were not affected significantly under the treatment of fungicide used. While, free amino acids recorded inverse these issues

**Enzyme Activities**

Peroxidase and polyphenol oxidase activities in faba bean plants were determined as shown in table (8). Salinity stimulated the activity of peroxidase, this effect increased gradually with increasing salinity levels, hence it was more pronounced at 5.5Mm. Giza843 recorded the highest values of peroxidase activity under different salinity levels. The external treatments of nicotinamide induced significant increase in peroxidase activity under different levels of salinity. The lowest concentration gave the highest values. Fungicide revealed low increase in these parameters. On the other side, polyphenol oxidase activity decreased significantly with increasing salinity levels. Moreover, it could be observed that, an additive effects of salinity on decreasing the activity of polyphenol oxidase were occurred. The lowest values occurred under nicotinamide at 200mg/l

**Yield Components**

Data concerning yield parameters(pods number plant-1,seed yield plant-1/g and 100 seed weight/g) as affected by abiotic stress (soil salinity) and biotic stress (*Alternaria alternata*) as well as the applications of fungicide (Tridex-80%) and two levels of nicotinamide are presented in table 9.All yield parameters decreased significantly with increasing salinity levels.Giza843 cultivar recorded the highest values of pods number plant-1 and plant seed yield, while Maser1 cultivar was the best in 100-seed weight. In both growing seasons, the application of nicotinamide increased significantly yield components in both cultivars under experimental levels of soil salinity. The low level (200 mg/l) gave the

highest values, while the fungicide had no significant effect on these parameters

## Discussion

The phenomenon of salinity is one of the main factors affecting spread of plants, especially in their natural habitats. Salinity causing an increase problem in arid and semi arid regions of the world (Shanon, 1986), where both of arid and semi arid represent around 40% of the earth's area. The high concentrations of salinity result in membrane injury and loss of permeability (DiBaccio *et al*., 2004; Dkhil and Denden, 2012). Faba bean (*Vicia faba* L.), is the most important legume crop and a major source of protein for human and animal nutrition (Crepon *et al*., 2010). Its cultivation leads to an increase of soil N compounds (Hungria and Vargas, 2000). The effects of salinity stress in bean at seedling stage causing reduction in germination percentage, fresh and dry weight of shoot and roots, as a result of decreasing the uptake of various nutrient ions (Azooz *et al*., 2011). The property of soil salinity tolerance is not a simple attribute but it is an outcome of various features that depend on different physiological interactions. There are different mechanisms contribute to salt tolerance of plants through compartment of ions in vacuoles, accumulation of osmotic solutes in cytoplasm and genetic salt resistance (Girija *et al*., 2002). Moreover, faba bean plants are infected with many fungal pathogens, which causes a considerable a yield losses during cultivation. One of such these diseases, being *Alternaria* leaf spot disease, where become predominant to faba bean in Egypt, during global climate changes (Reis *et al*., 2007; Juroszek, 2011). The management of such disease including chemical and biological procedures, agriculture practice and resistant cultivars have also been used (Hiremath and Sundaresh, 1985). The chemical control of *Alternaria* leaf spot has offered good results, but improper use of fungicides to environment which lead to hazard pollution as well as resistant isolates of *Alternaria* leaf spot (Kamble *et al*., 2000). Wherein, using nicotinamide as antioxidant vitamin has successful trials against salinity stress (Azooz *et al*., 2013), which acting as coenzymes systems with a role in metabolic regulation. As well as, it may be played a role in regulates secondary metabolic accumulation and/or manifestation of defense mechanism in plants (Berglund and Ohlsson, 1995), its effect could be extended to plant defensive gene transcription (Berglund, 1994). The use of such vitamin as antioxidant mediated salt tolerance as selection factor as well as a driving force for improving resistance and adaption to salt stress (Jochum *et al*., 2007). Additionally, these vitamin supplements with enhancing plant activities and did not have toxic or mutagenic action (Bronzetti *et al*., 2001). In the present study, nicotinamide at different concentrations (100, 200, 300 and 400 mg/l) was carried out against fungal leaf spot in compared to Tridex-80 (used at 1.5, 2.5 and 3.5 g/l) in vitro. The linear growth of *Alternaria alternata* as response to thresholds of both of nicotinamide and Tridex-80 (Fig1), indicated the efficacy of nicotinamide towards the fungal pathogen, in which the reduction% reached to 100% in growth of *Alternaria* at 400mg/l. Concerning germination percentage, results as shown in table (1), indicated the increase of germination percent in Giza843 compared to cultivar Maser1under stress and treatments. Likewise, both of nicotinamide and Tridex-80 showed positive impact on germination percentage. In which, the fungicide was more effective followed by low level of nicotinamide (200mg/l). Generally, both of Tridex-80 and nicotinamide decreased the negative effect of salinity on germination percent of faba bean seeds. These data are consistent with previous study of Azooz *et al*. (2013), which described nicotinamide as antioxidant vitamin with effective role in plant growth and development. Another study of Jochum *et al*. (2007) showed that, the use of vitamins as antioxidant mediated salt tolerance during driving force to improve resistance and adaption to salt stress. Further, there are significant gradual reduction in growth parameters with increasing of salinity level. Meanwhile, nicotinamide at two levels was significantly affected against salinity, where the low level more active compared to high level. Whereas, Tridex-80 showed no any significance towards plant height, branches number or leaflets number, however increases in fresh weight, shoot dry weight and leaflets have been obtained. Concerning diseases severity and incidence as response to treatments, Maser1 was more susceptible to infection. Higher levels of salinity increased both of disease severity and incidence. Foliar treatments with nicotinamide and Tridex-80 decreased significantly diseases incidence and severity under different levels of salinity. These results are conceding with De Gara *et al*. (2003), they stated that the antioxidant substances such as nicotinamide may activate metabolic pathway of infected cells in presence of pathogen and restricted it in plant tissues. Further, antioxidant substance may scavenging free radical that associated during pathogenesis process (Shahda, 2002). Additionally, the response in pigments, viz., chlorophyll a, b during nicotinamide thresholds may be due to the role of this vitamin as reduction of oxidative stress associated with salinity stress. Also, nicotinamide possess partial or completely ameliorated effect on photosynthetic pigments (Khan *et al*., 2006; Beltagi, 2008). Contrarily, the significant decreases were occurred during doses of salinity, these data in accordance with Azooz *et al*. (2013). The impact of salinity on pigments may be due to inhibition of

chlorophyll biosynthesis or increase of its degradation by chlorophyllase, which more active under salinity stress (Khan *et al*., 2006; AKca and Samsunlu, 2012). As well as, salinity stress causing deterioration in chloroplast structure and consequently decrease in chlorophyll content (Azooz *et al*., 2013). Interestingly, there are response increase in carotenoids content as increasing salinity levels. Regarding total phenol, proline and total soluble sugars content, the cultivar Giza843 recoded the highest values (Table6). Salinity showed gradual induction in these parameters. Low level of nicotinamide (200 mg/l) was superior to other treatments, which is more induction of these parameters. Likewise, significant response of polysaccharides, total carbohydrates and free amino acids has been recorded with lowest value of nicotinamide. However, no response in polysaccharides and total carbohydrates with fungicide thresholds (Table 7). Previous study reported that soluble carbohydrates, amino acids and proline may possess protective strategy to alleviate $Na^+$ toxicity (Chen *et al*., 2002). As well as, the accumulation of proline and amino acids in cytoplasm has important role in osmotic balance of plant and are good indicators of salinity tolerance (Bartels and Sunkar, 2005; Ramezani *et al*., 2011; Uiddin *et al*., 2012). The increase in amino acids and proline content as a result of salinity stress, may be magnified in response to nicotinamide, these data are in accordance with the earlier investigation (Azooz *et al*., 2004; Ferch *et al*., 2011). Similarly, Azzedine *et al*. (2011), investigated that the application of vitamin C was effective to mitigate the adverse effect of salt stress on plant growth of durum wheat, with increasing of leaf area and accumulation of proline. Nevertheless, proline is considered as compatible solute involved in osmotic adjustment at the plant cell levels (Lutts *et al*., 1996). Moreover, other studies pointed out that, proline accumulations in cytoplasm are not having any detrimental effect on cytosolic enzyme activities (Stewart and Lee, 1974). However, it has a role as energy storage, and displayed as antioxidant agent (Taie *et al*., 2013). Data as shown in table (8), indicated the antioxidant enzymes as response to salinity stress which stimulated the peroxidase enzyme under salinity levels. Contrarily, polyphenol oxidase decreased gradually with salinity increasing, while this enzyme decreased in appreciable amount under low dose of nicotinamide (200 mg/l). The positive correlation of a fore mentioned parameters measured was reflected on yield components as a result of thresholds of nicotinamide and fungicides application (Table 9) against salinity levels and *Alternaria* leaf spot disease. Where, nicotinamide increased significantly pods number plant-1 and seed weight yield in both growing seasons. The low threshold of nicotinamide (200 mg/l) was the best for higher productivity of yield. Meanwhile, the fungicide had no significance effect on above parameters. Generally, our investigation pointed out that nicotinamide has a direct effect on decreasing linear growth of *Alternaria alternata*, as well as increasing photosynthetic pigments, total phenol, proline and peroxidase activity. Where the increase of such these pigments and antioxidant enzymes help the plant tissues to be more resistant against pathogens and increase lignin production (Nawar and Kuti, 2003) and consequently increasing yield productivity

## Conclusions

Generally, utilization of salty soil to be cultivated can be achieved either by modulating the soil to meet plant demands or choice plant tolerant to soil salinity. Herein, this trial investigation is one of experiment to used nicotinamide with comparison of fungicide Tridex-80 to alleviate the harmful effect of salinity with the pathogen of *Alternaria* leaf spot on faba bean plants. Data obtained showed the efficacy of nicotinamide as antioxidant vitamins in mitigation of both effect of salinity and pathogen, by which the positive effect extended to germination percentage, plant growth characters, pigments, phenolic compounds and, finally yield crop. So, these data are recommended for usage of such this nicotinamide as antioxidant vitamin to be applied in this field of study under salinity stress.

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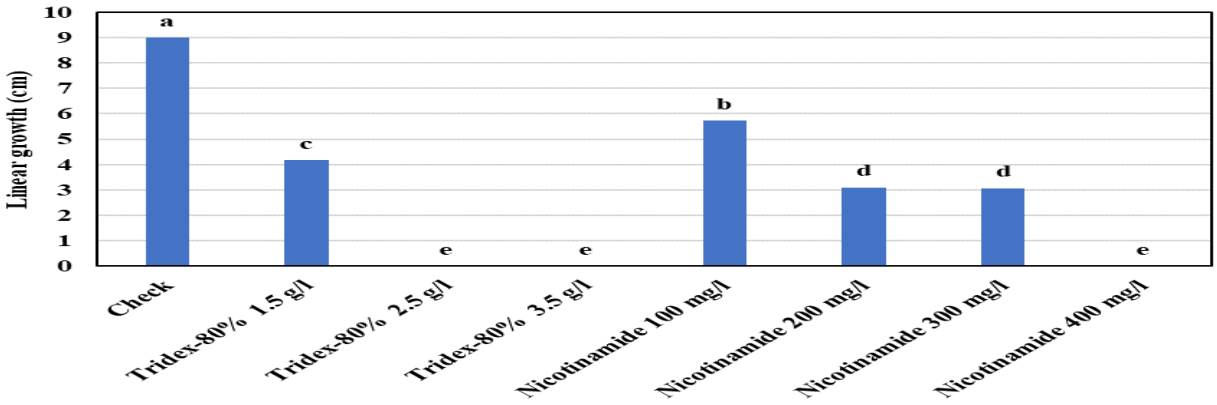


**Fig. 1 :** A linear growth of *Alternaria alternata* as a result of thresholds of nicotinamide and fungicide (Tridex-80)

**Table 1:** Germination percentage of faba bean seeds as response to thresholds of nicotinamide against three levels of salinity

| Treatments | | | Germination% | | | |
|---|---|---|---|---|---|---|
| | | | Season 1 | | Season 1 | |
| Salinity | | Level I | 87.33 | a | 87.535 | a |
| | | Level II | 81.04 | b | 80.635 | b |
| | | Level III | 68.55 | c | 68.395 | c |
| Variety | | Maser 1 | 71.61 | b | 74.22 | b |
| | | Giza 843 | 86.34 | a | 83.49 | a |
| Treatments | | Control | 72.72 | d | 72.62 | d |
| | | Fungicide | 84.58 | a | 84.28 | a |
| | | NA 200 mg/L | 81.46 | b | 81.46 | b |
| | | NA 400 mg/L | 77.14 | c | 77.06 | c |
| Level I | Maser 1 | Control | 75.18 | l | 77.35 | i |
| | | Fungicide | 90.21 | c | 92.64 | ab |
| | | NA 200 mg/L | 87.92 | d | 90.37 | c |
| | | NA 400 mg/L | 81.54 | ij | 83.91 | e |
| | Giza 843 | Control | 85.76 | ef | 83.95 | e |
| | | Fungicide | 95.44 | a | 93.09 | a |
| | | NA 200 mg/L | 93.55 | b | 91.65 | b |
| | | NA 400 mg/L | 89.04 | cd | 87.32 | d |
| Level II | Maser 1 | Control | 68.63 | n | 71.02 | l |
| | | Fungicide | 80.14 | j | 81.86 | f |
| | | NA 200 mg/L | 76.38 | l | 78.74 | h |
| | | NA 400 mg/L | 71.4 | m | 73.95 | k |
| | Giza 843 | Control | 83.07 | gh | 80.71 | g |
| | | Fungicide | 93.11 | b | 90.61 | c |
| | | NA 200 mg/L | 89.62 | c | 86.96 | d |
| | | NA 400 mg/L | 85.99 | e | 81.24 | fg |
| Level III | Maser 1 | Control | 48.19 | r | 50.8 | p |
| | | Fungicide | 64.31 | o | 66.76 | m |
| | | NA 200 mg/L | 58.96 | p | 62.73 | n |
| | | NA 400 mg/L | 56.45 | q | 60.55 | o |
| | Giza 843 | Control | 75.48 | l | 71.91 | l |
| | | Fungicide | 84.26 | fg | 80.75 | g |
| | | NA 200 mg/L | 82.34 | hi | 78.3 | hi |
| | | NA 400 mg/L | 78.4 | k | 75.37 | j |

For each of the individual, dual and interaction effect, means followed by the same letter(s) are not significantly differed at P ≤ 5

**Table 2 :** Plant height, branches and leaflets number of faba bean as affected by salinity levels and nicotinamide doses

| Treatments | | | Plant height | | | | No. of branches | | | | Leaflets number | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Season 1 | | Season 1 | | Season 1 | | Season 1 | | Season 1 | | Season 1 | |
| Salinity | | Level I | 82.33 | a | 100.13 | a | 4.67 | a | 5.13 | a | 69.08 | a | 80 | a |
| | | Level II | 74.75 | b | 84.05 | b | 4.2 | b | 4.67 | b | 65.83 | a | 72.55 | b |
| | | Level III | 66.42 | c | 70.63 | c | 3.67 | c | 4 | c | 48.42 | b | 50 | c |
| Variety | | Maser 1 | 69.89 | b | 81.28 | b | 3.94 | b | 4.11 | b | 58.19 | b | 63.25 | a |
| | | Giza 843 | 79.11 | a | 88.58 | a | 4.42 | a | 5.08 | a | 64.03 | a | 71.78 | b |
| Treatments | | Control | 69.83 | d | 76.78 | c | 3.94 | bc | 4.06 | c | 55.28 | c | 59.44 | c |
| | | Fungicide | 71.39 | c | 78.83 | c | 3.67 | c | 3.72 | d | 54.61 | c | 59.06 | c |
| | | NA 200 mg/L | 81.28 | a | 96.78 | a | 4.83 | a | 5.61 | a | 70.11 | a | 80.72 | a |
| | | NA 400 mg/L | 75.5 | b | 87.33 | b | 4.28 | b | 5 | b | 64.44 | b | 70.83 | b |
| Level I | Maser 1 | Control | 69.67 | ij | 84.33 | ef | 4.33 | bcd | 4 | ef | 61.33 | fgh | 67 | gh |
| | | Fungicide | 72 | hi | 85.67 | e | 4 | cde | 3.67 | f | 61 | gh | 67.67 | fg |
| | | NA 200 mg/L | 82 | de | 109.33 | b | 5 | ab | 5.67 | bc | 74.67 | bc | 89.33 | b |
| | | NA 400 mg/L | 78 | f | 98 | c | 4.67 | abc | 5 | cd | 71.67 | cd | 78.33 | de |
| | Giza 843 | Control | 83.67 | cd | 95.33 | cd | 4.67 | abc | 5 | cd | 65.67 | e | 76.67 | e |
| | | Fungicide | 84.67 | c | 99 | c | 4.33 | bcd | 5 | cd | 65 | e | 79.67 | de |
| | | NA 200 mg/L | 97.67 | a | 119 | a | 5.33 | a | 6.67 | a | 79.33 | a | 96.67 | a |
| | | NA 400 mg/L | 91 | b | 110.33 | b | 5 | ab | 6 | ab | 74 | bc | 84.67 | c |
| Level II | Maser 1 | Control | 65.67 | kl | 72 | ij | 3.67 | def | 4 | ef | 58.33 | hi | 66.67 | gh |
| | | Fungicide | 66.67 | k | 74.67 | hi | 3.33 | ef | 3.67 | f | 56.33 | ij | 63.67 | hi |
| | | NA 200 mg/L | 74.33 | gh | 94 | cd | 4.67 | abc | 5 | cd | 73 | c | 80.67 | d |
| | | NA 400 mg/L | 70.33 | i | 83 | efg | 4 | cde | 4.67 | de | 64.67 | e | 71 | f |
| | Giza 843 | Control | 75 | g | 79.67 | fgh | 4.33 | bcd | 4.67 | de | 64.33 | ef | 66.33 | gh |
| | | Fungicide | 76.67 | fg | 80.67 | efg | 4 | cde | 4 | ef | 64 | efg | 67.33 | g |
| | | NA 200 mg/L | 88.67 | b | 97.33 | c | 5 | ab | 6 | ab | 77 | ab | 87.33 | bc |
| | | NA 400 mg/L | 80.67 | e | 91 | d | 4.67 | abc | 5.33 | bcd | 69 | d | 77.33 | de |
| Level III | Maser 1 | Control | 61.33 | n | 62 | l | 3 | f | 2.67 | g | 37 | m | 32.67 | m |
| | | Fungicide | 63 | mn | 64.33 | kl | 3 | f | 2.33 | g | 36.67 | m | 30.67 | m |
| | | NA 200 mg/L | 70.33 | i | 78.33 | gh | 4.33 | bcd | 4.67 | de | 53.33 | jk | 59.33 | j |
| | | NA 400 mg/L | 65.33 | klm | 69.67 | ij | 3.33 | ef | 4 | ef | 50.33 | k | 52 | k |
| | Giza 843 | Control | 63.67 | lmn | 67.33 | jk | 3.67 | def | 4 | ef | 45 | l | 47.33 | l |
| | | Fungicide | 65.33 | klm | 68.67 | jk | 3.33 | ef | 3.67 | f | 44.67 | l | 45.33 | l |
| | | NA 200 mg/L | 74.67 | g | 82.67 | efg | 4.67 | abc | 5.67 | bc | 63.33 | efg | 71 | f |
| | | NA 400 mg/L | 67.67 | jk | 72 | ij | 4 | cde | 5 | cd | 57 | i | 61.67 | ij |

For each of the individual, dual and interaction effect, means followed by the same letter(s) are not significantly differed at $P \leq 5$

**Table 3:** Shoot fresh and shoot dry weights as well as leaf area index of faba bean during doses of nicotinamide and salinity

| Treatments | | | Shoot fresh weight | | | | Shoot Dry weight | | | | Leaf area | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Season 1 | | Season2 | | Season 1 | | Season 2 | | Season 1 | | Season 2 | |
| Salinity | | Level I | 74.4 | a | 68.67 | a | 33.93 | a | 36.5 | a | 1531 | a | 1226.88 | a |
| | | Level II | 57.15 | b | 56.08 | b | 26.43 | b | 27.73 | b | 1291.29 | b | 1024.33 | b |
| | | Level III | 42.28 | c | 45.13 | c | 21.85 | c | 20.55 | c | 1095.92 | c | 696.21 | c |
| Variety | | Maser 1 | 53.5 | b | 52.14 | b | 24.79 | b | 26.01 | b | 1222.17 | b | 882.5 | b |
| | | Giza 843 | 62.39 | a | 61.1 | a | 30.03 | a | 30.51 | a | 1389.97 | a | 1082.44 | a |
| Treatments | | Control | 49.08 | d | 47.16 | c | 21.41 | d | 22.45 | d | 1062.5 | d | 822.5 | c |
| | | Fungicide | 51.97 | c | 47.79 | c | 23.17 | c | 23.21 | c | 1135 | c | 838.89 | c |
| | | NA 200 mg/L | 70.37 | a | 70.01 | a | 35.14 | a | 36.7 | a | 1651.06 | a | 1254.56 | a |
| | | NA 400 mg/L | 60.35 | b | 61.53 | b | 29.91 | b | 30.69 | b | 1375.72 | b | 1013.94 | b |
| Level I | Maser 1 | Control | 58.63 | f | 53.97 | g | 22.7 | k | 27.87 | g | 1152.67 | m | 971 | fgh |
| | | Fungicide | 64.13 | e | 54.27 | g | 26.33 | h | 28.57 | g | 1194 | kl | 986.33 | fg |
| | | NA 200 mg/L | 81.23 | b | 77.83 | c | 39.47 | c | 43.43 | b | 1943 | b | 1328 | c |
| | | NA 400 mg/L | 72.23 | c | 65.37 | d | 34.53 | e | 36.17 | c | 1390.33 | g | 1181.67 | d |
| | Giza 843 | Control | 68.57 | d | 64.33 | d | 28.33 | g | 31.2 | f | 1208.33 | jk | 1129 | e |
| | | Fungicide | 72.43 | c | 64.27 | d | 30.97 | f | 32.2 | e | 1291.33 | h | 1141 | de |
| | | NA 200 mg/L | 96.33 | a | 88.93 | a | 48.4 | a | 49.07 | a | 2235.33 | a | 1730.33 | a |
| | | NA 400 mg/L | 81.67 | b | 80.4 | b | 40.73 | b | 43.53 | b | 1833 | c | 1347.67 | c |
| Level II | Maser 1 | Control | 43.8 | j | 41.6 | l | 18.57 | m | 21.03 | k | 1068 | o | 782.33 | j |
| | | Fungicide | 47.63 | i | 42.53 | kl | 20 | l | 21.6 | k | 1115.67 | n | 805.33 | j |
| | | NA 200 mg/L | 62.27 | e | 65.1 | d | 31.6 | f | 34.17 | d | 1423 | f | 1162.67 | de |
| | | NA 400 mg/L | 55 | g | 60.63 | e | 26.9 | h | 28.6 | g | 1233.33 | i | 943 | hi |
| | Giza 843 | Control | 52.87 | gh | 49 | i | 23.4 | jk | 23.67 | ij | 1125 | n | 954 | ghi |
| | | Fungicide | 54.4 | g | 49.73 | i | 24.2 | ij | 23.9 | i | 1207.67 | jkl | 989.67 | fg |
| | | NA 200 mg/L | 79.33 | b | 75.9 | c | 35.93 | d | 36.7 | c | 1676.67 | d | 1397.67 | b |
| | | NA 400 mg/L | 61.87 | e | 64.1 | d | 30.87 | f | 32.17 | e | 1481 | e | 1160 | de |
| Level III | Maser 1 | Control | 30.6 | m | 31.13 | m | 15.63 | n | 14.1 | n | 883.67 | r | 436 | l |
| | | Fungicide | 31.9 | m | 32.23 | m | 16.73 | n | 15 | n | 920.67 | q | 447.67 | l |
| | | NA 200 mg/L | 51.3 | h | 54.2 | g | 24.73 | i | 22.87 | j | 1216.67 | j | 913.33 | i |
| | | NA 400 mg/L | 43.23 | jk | 46.87 | j | 20.23 | l | 18.73 | l | 1125 | n | 632.67 | k |
| | Giza 843 | Control | 40 | l | 42.9 | kl | 19.8 | l | 16.83 | m | 937.33 | p | 662.67 | k |
| | | Fungicide | 41.33 | kl | 43.73 | k | 20.77 | l | 17.97 | l | 1080.67 | o | 663.33 | k |
| | | NA 200 mg/L | 51.77 | h | 58.1 | f | 30.73 | f | 33.97 | d | 1411.67 | f | 995.33 | f |
| | | NA 400 mg/L | 48.1 | i | 51.83 | h | 26.2 | h | 24.93 | h | 1191.67 | l | 818.67 | j |

For each of the individual, dual and interaction effect, means followed by the same letter(s) are not significantly differed at P ≤ 5

**Table 4:** Disease severity and incidence of faba bean as response to nicotinamide and salinity stress

| Treatments | | | Disease Severity | | | | Disease Incidence | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Season 1 | | Season 1 | | Season 1 | | Season 1 | |
| Salinity | | Level I | 19.79 | c | 24.04 | c | 11.71 | c | 15.92 | c |
| | | Level II | 25.13 | b | 29.83 | b | 15.08 | b | 19.54 | b |
| | | Level III | 33.67 | a | 39.42 | a | 21.38 | a | 27.46 | a |
| Variety | | Maser 1 | 23 | b | 34.972 | a | 18.22 | a | 23.11 | a |
| | | Giza 843 | 29.39 | a | 27.222 | b | 13.89 | b | 18.83 | b |
| Treatments | | Control | 50.83 | a | 56.39 | a | 30.67 | a | 37.67 | a |
| | | Fungicide | 8.111 | d | 11.78 | d | 5.28 | d | 8.72 | d |
| | | NA 200 mg/L | 19.11 | c | 23.78 | c | 11.5 | c | 15.17 | c |
| | | NA 400 mg/L | 26.72 | b | 32.44 | b | 16.78 | b | 22.33 | b |
| Level I | Maser 1 | Control | 45.67 | d | 53.33 | d | 26.33 | d | 31.67 | d |
| | | Fungicide | 7.67 | p | 9.67 | n | 4.33 | lm | 7.67 | no |
| | | NA 200 mg/L | 14.33 | lm | 19 | kl | 9.67 | j | 13 | jkl |
| | | NA 400 mg/L | 21.33 | ij | 26.33 | i | 14.33 | h | 19.67 | gh |
| | Giza 843 | Control | 37.67 | e | 40.33 | g | 19.67 | e | 24 | f |
| | | Fungicide | 4.33 | q | 7 | o | 2.67 | m | 4.67 | o |
| | | NA 200 mg/L | 10.33 | no | 14 | m | 6.67 | k | 10.67 | lmn |
| | | NA 400 mg/L | 17 | k | 22.67 | j | 10 | j | 16 | ijk |
| Level II | Maser 1 | Control | 55 | b | 59.67 | b | 31.67 | c | 38.33 | c |
| | | Fungicide | 10.33 | no | 14.33 | m | 5.33 | kl | 9.33 | mn |
| | | NA 200 mg/L | 20 | j | 23.33 | j | 12 | i | 16.33 | hij |
| | | NA 400 mg/L | 26.67 | h | 34.33 | h | 17.67 | fg | 21.33 | fg |
| | Giza 843 | Control | 44.67 | d | 49.67 | e | 27.33 | d | 32.67 | d |
| | | Fungicide | 6.33 | pq | 9.33 | no | 4 | lm | 7.33 | no |
| | | NA 200 mg/L | 15.33 | kl | 20 | k | 9.67 | j | 12.33 | lm |
| | | NA 400 mg/L | 22.67 | i | 28 | i | 13 | hi | 18.67 | ghi |
| Level III | Maser 1 | Control | 69.67 | a | 79 | a | 44.67 | a | 56 | a |
| | | Fungicide | 12 | mn | 17.33 | l | 9 | j | 12.67 | klm |
| | | NA 200 mg/L | 31.67 | g | 38.33 | g | 17.33 | g | 20.67 | fg |
| | | NA 400 mg/L | 38.33 | e | 45 | f | 26.33 | d | 30.67 | de |
| | Giza 843 | Control | 52.33 | c | 56.33 | c | 34.33 | b | 43.33 | b |
| | | Fungicide | 8 | op | 13 | m | 6.33 | k | 10.67 | lmn |
| | | NA 200 mg/L | 23 | i | 28 | i | 13.67 | hi | 18 | ghi |
| | | NA 400 mg/L | 34.33 | f | 38.33 | g | 19.33 | ef | 27.67 | e |

For each of the individual, dual and interaction effect, means followed by the same letter(s) are not significantly differed at $P \leq 5$

**Table 5 :** Chlorophyll a, b and carotenoids of faba bean as affected by salinity levels and nicotinamide thresholds

| Treatments | | | Ch a | | Ch b | | Carotenoid | |
|---|---|---|---|---|---|---|---|---|
| Salinity | | Level I | 1.34 | a | 0.93 | a | 0.45 | a |
| | | Level II | 1.22 | b | 0.86 | b | 0.37 | b |
| | | Level III | 0.95 | c | 0.74 | c | 0.3 | c |
| Variety | | Maser 1 | 1.1 | b | 0.8 | b | 0.33 | b |
| | | Giza 843 | 1.24 | a | 0.88 | a | 0.41 | a |
| Treatments | | Control | 1.1 | d | 0.77 | d | 0.33 | d |
| | | Fungicide | 1.17 | b | 0.85 | b | 0.37 | b |
| | | NA 200 mg/L | 1.28 | a | 0.93 | a | 0.44 | a |
| | | NA 400 mg/L | 1.13 | c | 0.81 | c | 0.35 | c |
| Level I | Maser 1 | Control | 1.19 | i | 0.77 | j | 0.31 | n |
| | | Fungicide | 1.25 | f | 0.91 | ef | 0.35 | l |
| | | NA 200 mg/L | 1.34 | d | 0.97 | c | 0.38 | j |
| | | NA 400 mg/L | 1.22 | h | 0.85 | h | 0.33 | m |
| | Giza 843 | Control | 1.35 | d | 0.91 | ef | 0.23 | s |
| | | Fungicide | 1.44 | b | 0.98 | bc | 0.26 | q |
| | | NA 200 mg/L | 1.54 | a | 1.07 | a | 0.33 | m |
| | | NA 400 mg/L | 1.39 | c | 0.95 | d | 0.25 | r |
| Level II | Maser 1 | Control | 1.08 | l | 0.73 | k | 0.37 | jk |
| | | Fungicide | 1.15 | j | 0.83 | h | 0.43 | ef |
| | | NA 200 mg/L | 1.25 | fg | 0.93 | de | 0.5 | c |
| | | NA 400 mg/L | 1.11 | k | 0.77 | j | 0.4 | h |
| | Giza 843 | Control | 1.23 | gh | 0.85 | h | 0.28 | p |
| | | Fungicide | 1.29 | e | 0.91 | f | 0.3 | o |
| | | NA 200 mg/L | 1.4 | c | 0.99 | b | 0.38 | j |
| | | NA 400 mg/L | 1.25 | f | 0.88 | g | 0.29 | o |
| Level III | Maser 1 | Control | 0.84 | r | 0.67 | n | 0.42 | fg |
| | | Fungicide | 0.92 | p | 0.7 | lm | 0.47 | d |
| | | NA 200 mg/L | 1.01 | m | 0.8 | i | 0.55 | a |
| | | NA 400 mg/L | 0.88 | q | 0.68 | mn | 0.44 | e |
| | Giza 843 | Control | 0.94 | o | 0.72 | kl | 0.36 | k |
| | | Fungicide | 0.96 | n | 0.77 | j | 0.42 | g |
| | | NA 200 mg/L | 1.12 | k | 0.84 | h | 0.51 | b |
| | | NA 400 mg/L | 0.95 | o | 0.74 | k | 0.39 | i |

For each of the individual, dual and interaction effect, means followed by the same letter(s) are not significantly differed at $P \leq 5$

**Table 6 :** Total phenol, proline and total soluble sugars of faba bean as a result of nicotinamide and salinity stress

| Treatments | | | Total Phenol | | Proline | | TSS | |
|---|---|---|---|---|---|---|---|---|
| Salinity | | Level I | 598.25 | c | 0.51 | c | 5.36 | c |
| | | Level II | 645.67 | b | 0.56 | b | 5.57 | b |
| | | Level III | 704.92 | a | 0.61 | a | 5.89 | a |
| Variety | | Maser 1 | 635.86 | b | 0.54 | b | 5.52 | b |
| | | Giza 843 | 663.36 | a | 0.58 | a | 5.69 | a |
| Treatments | | Control | 611.17 | b | 0.5 | c | 5.3 | c |
| | | Fungicide | 624.5 | b | 0.51 | c | 5.25 | c |
| | | NA 200 mg/L | 693.78 | a | 0.65 | a | 6.04 | a |
| | | NA 400 mg/L | 669 | a | 0.57 | b | 5.83 | b |
| Level I | Maser 1 | Control | 544.33 | k | 0.45 | n | 5.1 | l |
| | | Fungicide | 561 | jk | 0.45 | n | 5.11 | l |
| | | NA 200 mg/L | 618 | ghij | 0.57 | gh | 5.6 | fgh |
| | | NA 400 mg/L | 581 | ijk | 0.51 | l | 5.42 | hij |
| | Giza 843 | Control | 598 | hijk | 0.47 | m | 5.15 | kl |
| | | Fungicide | 576.33 | ijk | 0.48 | m | 5.15 | kl |
| | | NA 200 mg/L | 681.67 | cdef | 0.6 | ef | 5.78 | ef |
| | | NA 400 mg/L | 625.67 | fghi | 0.53 | ijk | 5.54 | gh |
| Level II | Maser 1 | Control | 602 | hijk | 0.48 | m | 5.21 | kl |
| | | Fungicide | 617 | ghij | 0.49 | m | 5.22 | jkl |
| | | NA 200 mg/L | 694 | bcde | 0.62 | d | 5.92 | de |
| | | NA 400 mg/L | 669.33 | defg | 0.55 | i | 5.67 | fg |
| | Giza 843 | Control | 618 | ghij | 0.53 | jk | 5.31 | ijkl |
| | | Fungicide | 649.67 | defgh | 0.54 | ij | 5.32 | ijk |
| | | NA 200 mg/L | 631.33 | efghi | 0.68 | b | 6.12 | cd |
| | | NA 400 mg/L | 684 | bcdef | 0.59 | fg | 5.79 | ef |
| Level III | Maser 1 | Control | 638 | efghi | 0.52 | kl | 5.26 | ijkl |
| | | Fungicide | 655.67 | defgh | 0.53 | jk | 5.27 | ijkl |
| | | NA 200 mg/L | 741 | abc | 0.69 | b | 6.31 | abc |
| | | NA 400 mg/L | 709 | bcd | 0.6 | e | 6.2 | bc |
| | Giza 843 | Control | 666.67 | defg | 0.57 | h | 5.76 | ef |
| | | Fungicide | 687.33 | bcdef | 0.57 | gh | 5.43 | hi |
| | | NA 200 mg/L | 796.67 | a | 0.73 | a | 6.52 | a |
| | | NA 400 mg/L | 745 | ab | 0.66 | c | 6.36 | ab |

For each of the individual, dual and interaction effect, means followed by the same letter(s) are not significantly differed at $P \leq 5$

**Table 7 :** Polysaccharides, total carbohydrates and free amino acids content of faba bean as affected by nicotinamide and salinity stress

| Treatments | | | Polysaccharide | | Total carbohydrates | | Free amino acid | |
|---|---|---|---|---|---|---|---|---|
| Salinity | | Level I | 28.21 | a | 40.04 | a | 6.81 | c |
| | | Level II | 22.21 | b | 32.75 | b | 10.02 | b |
| | | Level III | 15 | c | 27 | c | 12.14 | a |
| Variety | | Maser 1 | 23.19 | a | 31.14 | b | 9.06 | b |
| | | Giza 843 | 20.42 | b | 35.39 | a | 10.25 | a |
| Treatments | | Control | 19.28 | c | 29.5 | d | 8.6 | d |
| | | Fungicide | 19.22 | c | 30.39 | c | 8.85 | c |
| | | NA 200 mg/L | 25.83 | a | 39.11 | a | 11.49 | a |
| | | NA 400 mg/L | 22.89 | b | 34.06 | b | 9.67 | b |
| Level I | Maser 1 | Control | 27.67 | c | 34.67 | f | 5.66 | r |
| | | Fungicide | 27.33 | c | 35.33 | f | 5.77 | r |
| | | NA 200 mg/L | 32.67 | a | 44 | b | 7.4 | o |
| | | NA 400 mg/L | 30 | b | 39.67 | d | 6.2 | q |
| | Giza 843 | Control | 25.67 | de | 37.67 | e | 6.24 | pq |
| | | Fungicide | 25 | de | 38.67 | de | 6.46 | p |
| | | NA 200 mg/L | 30 | b | 48 | a | 9.03 | l |
| | | NA 400 mg/L | 27.33 | c | 42.33 | c | 7.71 | n |
| Level II | Maser 1 | Control | 21.33 | f | 27 | ij | 8.75 | m |
| | | Fungicide | 21.33 | f | 28 | i | 8.86 | lm |
| | | NA 200 mg/L | 27.33 | c | 34.67 | f | 11.12 | g |
| | | NA 400 mg/L | 24.67 | e | 30.67 | h | 9.63 | j |
| | Giza 843 | Control | 16 | h | 31.33 | gh | 9.27 | k |
| | | Fungicide | 16.33 | h | 32.67 | g | 9.5 | jk |
| | | NA 200 mg/L | 26.33 | cd | 41.67 | c | 12.66 | d |
| | | NA 400 mg/L | 24.33 | e | 36 | f | 10.36 | i |
| Level III | Maser 1 | Control | 14 | i | 21.67 | l | 10.21 | i |
| | | Fungicide | 14.33 | i | 22 | l | 10.74 | h |
| | | NA 200 mg/L | 20.33 | f | 30.33 | h | 13.5 | b |
| | | NA 400 mg/L | 17.33 | gh | 25.67 | jk | 10.89 | gh |
| | Giza 843 | Control | 11 | j | 24.67 | k | 11.49 | f |
| | | Fungicide | 11 | j | 25.67 | jk | 11.79 | e |
| | | NA 200 mg/L | 18.33 | g | 36 | f | 15.24 | a |
| | | NA 400 mg/L | 13.67 | i | 30 | h | 13.25 | c |

For each of the individual, dual and interaction effect, means followed by the same letter(s) are not significantly differed at $P \leq 5$

**Table 8:** Peroxidase and polyphenol oxidase activities of two cultivars of faba bean under thresholds of nicotinamide and salinity

| Treatments | | | Peroxidase | | Poly phenol oxidase | |
|---|---|---|---|---|---|---|
| Salinity | | Level I | 11.35 | c | 16.96 | a |
| | | Level II | 14.17 | b | 9.05 | b |
| | | Level III | 18.21 | a | 4.98 | c |
| Variety | | Maser 1 | 13.75 | b | 11.31 | a |
| | | Giza 843 | 15.4 | a | 9.35 | b |
| Treatments | | Control | 13.36 | d | 11.6 | a |
| | | Fungicide | 13.55 | c | 11.32 | b |
| | | NA 200 mg/L | 16.46 | a | 8.7 | d |
| | | NA 400 mg/L | 14.91 | b | 9.71 | c |
| Level I | Maser 1 | Control | 9.33 | t | 19.67 | a |
| | | Fungicide | 9.46 | t | 19.3 | b |
| | | NA 200 mg/L | 12.54 | o | 16.07 | d |
| | | NA 400 mg/L | 10.48 | s | 17.27 | c |
| | Giza 843 | Control | 11.08 | r | 17.27 | c |
| | | Fungicide | 11.2 | r | 17.13 | c |
| | | NA 200 mg/L | 13.92 | l | 14.07 | f |
| | | NA 400 mg/L | 12.75 | n | 14.93 | e |
| Level II | Maser 1 | Control | 12.12 | q | 11.7 | g |
| | | Fungicide | 12.36 | p | 11.3 | h |
| | | NA 200 mg/L | 15.11 | k | 8.73 | j |
| | | NA 400 mg/L | 13.18 | m | 10.37 | i |
| | Giza 843 | Control | 13.89 | l | 8.57 | jk |
| | | Fungicide | 14.01 | l | 8.33 | k |
| | | NA 200 mg/L | 16.86 | g | 6.37 | n |
| | | NA 400 mg/L | 15.81 | j | 7.07 | l |
| Level III | Maser 1 | Control | 16.28 | i | 6.7 | m |
| | | Fungicide | 16.56 | h | 6.37 | n |
| | | NA 200 mg/L | 19.58 | b | 3.77 | r |
| | | NA 400 mg/L | 18 | d | 4.53 | p |
| | Giza 843 | Control | 17.49 | f | 5.7 | o |
| | | Fungicide | 17.74 | e | 5.47 | o |
| | | NA 200 mg/L | 20.77 | a | 3.2 | s |
| | | NA 400 mg/L | 19.22 | c | 4.07 | q |

For each of the individual, dual and interaction effect, means followed by the same letter(s) are not significantly differed at $P \leq 5$

**Table 9 :** Pods number/plant., plant seed yield and 100 seed weight of faba bean cultivars under nicotinamide and salinity stress

| Treatments | | | Pods Number/plant | | | | Plant seed yield | | | | 100-seed weight | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Season 1 | | Season 1 | | Season 1 | | Season 1 | | Season 1 | | Season 1 | |
| Salinity | | Level I | 54.83 | a | 62.13 | a | 80.96 | a | 83.13 | a | 63.42 | a | 64.25 | a |
| | | Level II | 41.71 | b | 48.92 | b | 61 | b | 63.33 | b | 58.75 | b | 59.75 | b |
| | | Level III | 24.71 | c | 33.04 | c | 42.88 | c | 46.38 | c | 55.38 | c | 57.04 | c |
| Variety | | Maser 1 | 36.28 | b | 42.39 | b | 58.06 | b | 60.31 | b | 60.81 | a | 61.81 | a |
| | | Giza 843 | 44.56 | a | 53.67 | a | 65.17 | a | 68.25 | a | 57.56 | b | 58.89 | b |
| Treatments | | Control | 33.22 | d | 40.17 | c | 58.39 | d | 61 | c | 58.33 | b | 59.33 | c |
| | | Fungicide | 34.94 | c | 41.28 | c | 59.33 | c | 61.83 | c | 58.56 | b | 59.67 | c |
| | | NA 200 mg/L | 50.39 | a | 59.28 | a | 65.83 | a | 68.83 | a | 60 | a | 61.61 | a |
| | | NA 400 mg/L | 43.11 | b | 51.39 | b | 62.89 | b | 65.44 | b | 59.83 | a | 60.78 | b |
| Level I | Maser 1 | Control | 41.67 | gh | 48 | e | 73.33 | d | 75 | f | 64.33 | ab | 64.67 | bc |
| | | Fungicide | 44.33 | fg | 49.67 | e | 74.67 | d | 75.67 | f | 64.67 | a | 65 | bc |
| | | NA 200 mg/L | 60.67 | bc | 68.33 | b | 81 | b | 83.33 | d | 65.33 | a | 66.33 | a |
| | | NA 400 mg/L | 51.67 | de | 55.67 | d | 77.33 | c | 79.33 | e | 65 | a | 65.33 | ab |
| | Giza 843 | Control | 52.67 | d | 62 | c | 82.33 | b | 85.33 | cd | 61.33 | de | 62.33 | ef |
| | | Fungicide | 53.67 | d | 63 | c | 83 | b | 86 | c | 61.67 | cde | 63 | def |
| | | NA 200 mg/L | 71.33 | a | 80.67 | a | 88.33 | a | 91.67 | a | 63 | bc | 64 | cd |
| | | NA 400 mg/L | 62.67 | b | 69.67 | b | 87.67 | a | 88.67 | b | 62 | cd | 63.33 | de |
| Level II | Maser 1 | Control | 31.67 | l | 35.33 | h | 55 | i | 56.67 | j | 60.33 | e | 61 | g |
| | | Fungicide | 34 | kl | 36.33 | h | 56 | i | 57.33 | j | 60.33 | e | 61 | g |
| | | NA 200 mg/L | 45.67 | f | 56.33 | d | 60 | gh | 62.33 | hi | 62 | cd | 63.33 | de |
| | | NA 400 mg/L | 40.33 | hi | 46.67 | ef | 58.33 | h | 60.67 | i | 61.33 | de | 62 | fg |
| | Giza 843 | Control | 36.33 | jk | 42 | g | 60.33 | gh | 62.67 | hi | 55.67 | hi | 56.67 | k |
| | | Fungicide | 38.33 | ij | 43.67 | fg | 61.33 | g | 63 | h | 56 | ghi | 56.67 | k |
| | | NA 200 mg/L | 58 | c | 68.67 | b | 70.67 | e | 74.67 | f | 57.67 | f | 59 | hi |
| | | NA 400 mg/L | 49.33 | e | 62.33 | c | 66.33 | f | 69.33 | g | 56.67 | fgh | 58.33 | ij |
| Level III | Maser 1 | Control | 16.33 | p | 24 | k | 37 | n | 39.33 | p | 55.33 | hi | 56.67 | k |
| | | Fungicide | 17.67 | op | 25 | k | 38 | n | 41.67 | o | 55.67 | hi | 57.33 | jk |
| | | NA 200 mg/L | 28.33 | m | 33.33 | hi | 45.67 | k | 47.67 | m | 57.33 | fg | 59.67 | h |
| | | NA 400 mg/L | 23 | n | 30 | ij | 40.33 | m | 44.67 | n | 58 | f | 59.33 | hi |
| | Giza 843 | Control | 20.67 | no | 29.67 | j | 42.33 | lm | 47 | m | 53 | j | 54.67 | l |
| | | Fungicide | 21.67 | n | 30 | ij | 43 | l | 47.33 | m | 53 | j | 55 | l |
| | | NA 200 mg/L | 38.33 | ij | 48.33 | e | 49.33 | j | 53.33 | k | 54.67 | i | 57.33 | jk |
| | | NA 400 mg/L | 31.67 | l | 44 | fg | 47.33 | jk | 50 | l | 56 | ghi | 56.33 | k |

For each of the individual, dual and interaction effect, means followed by the same letter(s) are not significantly differed at $P \leq 5$

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