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Impact of Naphthalene Acetamide Application on Some Agronomic Traits of Large Seed Mungbean Varieties in Sandy Soil

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Abstract: The importance of mungbean in both agricultural and food industries suggests that mungbean should be further cultivated and improved in terms of different uses as seed and forage crop, however, the initial characterization is necessary to ensure the adaptability of germplasm to achieve satisfied yields. One of the main problems which determine yield is lower pod setting due to the inter plant competition on the assimilates. It is evident that growth regulators including auxins may improve growth and yield of legumes. Therefore, in this study, two field experiments were carried out during summer seasons of 2022 and 2023 in Researches and Production Station of National Research Centre (NRC), Al-Nubaria District, Al Behaira Governorate, Egypt to investigate the role of naphthalene acetamide (NAD) at different levels of (0, 30, and 60 mg L^{-1}) to maximize the growth, seed yield and its related traits as well as protein content of four large seed mungbean genotypes(100- seeds >4 gm) namely, (D1, L12, L20 and L30) were grown under sandy soil conditions. The results indicate that L20 genotype surpassed the other mungbean genotypes in seed yield (1.549 ton ha^{-1}) and protein yield (0.397 ton ha^{-1}). Maximum seed yield (1.425 ton ha^{-1}) and protein yield (0.351 ton ha^{-1}) were obtained by the highest foliar application level of naphthalene acetamide (60 mg L^{-1}). The interaction between L20 genotype and the foliar application of naphthalene acetamide at rate of (60 mg L^{-1}) gave the highest values of seed yield and protein yield (1.610 and 0.417 ton ha^{-1}) under the conditions of this trail.

Key words: Mungbean・Varieties・Naphthalene Acetamide・Agronomic traits

INTRODUCTION

Mungbean (*Vigna radiata* L. wilezek) or green gram is a leguminous food crop grown in many regions of the world, especially in Asia and East Africa. It is green with husk and yellow when dehusked. The seeds are small, ovoid in form and green in color.

The main regions for mungbean cultivation are China, Korea, South Asia, Southeast Asia, Bangladesh, India, and Pakistan. Mungbean is a summer pulse crop that has a high nutritive content and a short duration of growth (60-90 days), with 22-28% protein, 60-65% carbohydrates, 1-1.5% fat, 3.5-4.5% fiber, and 4.5-5.5 % ash, the seeds of mungbean has many active uses. It can be cooked like peas or sprouts, which are rich in vitamins and amino acids. Mungbean can be referred to as the "poor man's meat" since it is essential to human nutrition, generally because it is a good source of protein and bioactive compounds. It also meets the protein requirements of the deprived[1]. It is an excellent source of carbohydrates, proteins, and vitamins, great source of foliate, or vitamin B9 [2]. In addition to its nutritional value, mungbean helps in biological nitrogen fixation, which maintains the fertility of the soil [3, 4].This crop has the dual benefits of being a good source of seed and fodder due to its high biomass production and its ability to recover from grazing and produce an abundance of seeds. Also it can be used as vegetable crop [5]. Furthermore, it can be fed to broiler chickens as an unconventional feed item.

In addition to Kawmy-1, the Egyptian local registered variety, several researchers reported significant differences between mungbean varieties [5, 6, 7]. These reports concerned the adaptation of an Australian variety (King) to Egyptian conditions and the importation

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of specific genotypes from Taiwan (AVRDC). These genotypes were recommended as promising varieties in numerous regions.

One of the most problems facing mungbean wide spreading in Egypt is small seed size of the higher yielding varieties like Kawmy-1. Abd El lateef *et al.* [8] reported that although small seed size genotypes exceeded the large seed yield $^{-1}$, large seed genotypes with high yield potentiality are favored.

Synthetic plant growth regulators belonging to the auxin family are naphthalene acetic acid (NAA) and naphthalene acetamide (NAD). According to Thanaa *et al*. [9], functions include stimulating cell division, elongating cells, elongating shoots, photosynthesis, RNA synthesis, membrane permeability, and water uptake. These processes are involved in a number of physiological processes, including fruit set, flower induction, delayed senescence, resistance to bud sprouting, leaves chlorophyll content, and maximized yield. The endogenous hormonal pattern of a plant is influenced by the exogenous application of either synthetic or naturally occurring plant growth regulators. This can occur through the supplementation of low levels or through interactions with the synthesis, translocation, or inactivation of existing hormone levels [10]. Fruit quality and production were improved, the fruit setting ratio was raised, and fruit falling was prevented by foliar application of NAA and NAD [11]. According to Taiz and Zeiger [12], auxins may control a number of processes including cell elongation, cell division, tissue swelling, adventitious root development, callus initiation, induction of embryogenesis, and the promotion of cell wall loosening at extremely low concentrations.In mungbean plants, indole-3-acetic acid (IAA) is the primary auxin that is mostly generated in the bud's apex and young leaves of the shoot. According to research by El Karamany et al. [13], this hormone is also produced in other meristematic tissues, flowers, fruits, and immature seeds.

Naphthalene acetic acid (NAA) treatments can improve flower sex ratio, reduce fruit dropping, and raise fruit setting ratio. Additionally, it has been found that foliar NAA management increases plant height, number of leaves per plant, and fruit size, all of which increase seed production in different crops [14]. The maximum 1000-seed weights, seed yield and harvest index were found when mungbean was treated with 40 ppm NAA. Therefore, yield of mungbean can be improved by applying NAA [15]. Indole-3-acetic acid (IAA) is an auxin that is an important endogenous growth regulator in plants. It has been associated with several developmental processes and adaptive responses, such as cambial activity, polar development, elongation growth, gravitropism, and phototropism, in that order [16, 17]. Moreover, auxin precursor indole-3-acetamide can be used to manufacture IAA [18].

The objective of this study is to studythe impact of synthetic Naphthalene Acetamide application on some agronomic traits of four large seed mungbean genotypes in sandysoil to optimize the growth, seed yield, associated traits, and protein content.

MATERIAL AND METHODS

In the summers of 2022 and 2023, two field experiments were conducted at the National Research Centre's (NRC), Research and Production Station in Nubaria District, Al Behaira Governorate, Egypt (latitude 30o 30' 1.4' N, longitude 30o 19' 10.9" E, and 21 mmean sea level). Before every experiment, soil samples were taken at a depth of 30 cm, then the samples were analyzed using the procedures of Carter and Gregorich [19], organic matter content0.22 %, a $CaCO_3$ content of 2.5%, an electrical conductivity of 0.12 mhos/cm^3, and the availabile N 18.0 ppm , P18.0 ppm , K104 ppm , and 0.05 ppm of Zn. Sand composed 88.7 %, clay 6.6 % and silt 4.7 % of the soil, with pH of 8.2.

The experimental design was split- plot one in three replications, where the four mungbean genotypes (D1, L12, L20 and L30), were located in main plots and naphthalene acetamide (NAD) with (0, 30, and 60 mg L^{-1}) concentrations were randomly treated in sub-plots and carried out twice after 20 and 35 days from sowing date. The plot area was 10.5 m^2 consist of five rows (3.5 m length and 60 cm between rows).

The genotypes used were imported from Asian-Vegetable Research for Development Centre (AVRDC), evaluated and adapted by Field Crops Research Department, National Research Centre, Egypt Seeds of four mungbean genotypes were inoculated with a specific strain of bacteria and hand hills 0.30 m seeded in between (2 seeds/hill in both sides of rows) on the 1stand 10th of June in both seasons. The soil was immediately irrigated after sowing using drip irrigation system. Fertilization of NPK at a rate of (80:75:57) kg ha^{-1} in the form of ammonium nitrate 33% N; superphosphate 15.5% P_2O_5 and potassium sulfate 48% K_2O. Other cultural practices were applied as e recommended for mungbean.

At harvest (90 DAS) 10 plants from each central plot were randomly taken for yield components measure of the following characters were determined:

- plant height (cm); leaves, branches, and Pods no/plant; Seeds no./pod; 100-seed weight (g);Pods weight/plant(g); seed yield/plant (g) and Biological yield/plant (g)
- The whole yield of each plot (10.5 m^2) was harvested for character to calculate: Seed yield (ton ha^{-1}); Straw yield (ton ha^{-1}); Biological yield (ton ha^{-1}); Protein Yield (ton ha^{-1}) and Harvest index %;
- Protein %: Nitrogen and protein contents were determined with micro Kjeldahl's apparatus according to the method described by AOAC [20]. Crude protein was determined according to Bradford [21] (multiplying nitrogen contents by 6.25).

Statistical Analysis: In accordance with Snedecor and Cochran's [22], the data were statistically analyzed using randomized complete block design (RCBD) arrangement in split plot. Following Bartlett's test for homogeneity, a combined study of the two growing seasons was conducted. At 0.05 % percent probability levels, means were compared using the least significant difference (LSD). Minitab (2013) ver. 17.1.0.0 for windows was used to analyze the results.

RESULTS AND DISCUSSION

Effect of Varietal Differences: The varietal differences in seed yield and its components of the four tested mungbean varieties are presented in Table (1). Data show significance differences (p = 0.05)among the four tested mungbean genotypes. L20 genotype surpassed the other mungbean genotypes in seed yield (1.549 ton ha^{-1}) and protein yield (0.397 ton ha^{-1}). These increases were due to the increase in plant height (69.08 cm), biological yield/plant (114.42 g), pod weight/plant (40.08 g), number of branches, leaves /plant and number of seeds per pod (3.75, 14.92 and 7.50), Protein % and Harvest index (26.68 %). These significant variations among the four mungbean varieties may be due to the genetic differences of those varieties, origin, growth habit and genetic built-up of the variety in respect of yield potential. It is worthy to mention L20genotype showed more adaptation to the conditions of sandy soil than other varieties that adaptation reflected on the highest significant value of seed and protein yields per hectare. While, L30 genotype surpassed the other mungbean genotypes in biological and straw yields (7.855 and 6.627 ton ha^{-1}). These increase were due to the increase in 100 seed weight (6.86 g) and seed yield/plant (19.91 g) or for the in the number of plants per unit area .The obtained results are in agreement with those obtained by [13, 23] they mentioned that significantly higher yield mightbe due to genetic built-up of the variety in respect of yield potential. Australian variety (King) and some selected genotypes imported from (AVRDC) Taiwan were adapted under Egyptian conditions and recommended by them aspromising varieties in many regions beside Kawmy-1 the Egyptian local registered variety [6, 7, 24, 25, 26]. Plants of Kawmy-1 variety gave the highest number of pods per plant and the highest values of harvest index and seed protein content, while King variety had the highest values for number of branches, seed yield, biological yield, and seed index [26].

Effect of Naphthalene Acetamide (NAD) Treatments: The results in Table (2) showed the exposure of mungbean

Table 1: Effect of variety on mungbean growth, seed yield and its related traits and protein content in sandy soil. (Combined data over two seasons 2022 and 2023).

Traits	Varieties D1	L12	L20	L30	$LSD_{0.05}$
Plant height (cm)	61.830	66.000	69.080	65.330	1.760
Biological yield/plant (g)	80.330	91.020	114.420	94.520	0.780
Pod weight/plant (g)	33.670	38.140	40.080	36.260	0.930
No of Branches/plant	2.420	3.170	3.750	2.670	0.130
No of Leaves/plant	12.080	13.670	14.920	13.920	0.300
No of pods/plant	36.750	41.500	36.580	38.250	0.440
No of seeds/ pod	7.250	6.670	7.250	7.330	0.890
100 seed weight (g)	5.800	6.550	6.450	6.860	0.100
Seed yield/plant (g)	15.730	18.790	17.160	19.910	0.530
Seed yield (ton ha^{-1})	1.353	1.360	1.550	1.257	0.030
Straw yield (ton ha^{-1})	4.587	6.077	4.297	6.627	0.220
Biological yield (ton ha^{-1})	5.940	7.437	5.847	7.883	0.260
Protein %	24.620	23.000	25.610	21.040	0.260
Protein Yield (ton ha^{-1})	0.333	0.313	0.397	0.265	0.006
Harvest index %	22.800	18.310	26.640	15.930	0.580

Table 2: Effect of naphthalene acetamide (NAD) treatments on mungbean growth, seed yield and its related traits and protein content in sandy soil. (Combined data of two seasons 2022 and 2023).

	Naphthalene Acetamide (NAD) (mg L^{-1})			
Traits	0.00	30	60	LSD $_{0.05}$
Plant height (cm)	60.440	64.380	71.880	0.800
Biological yield/plant (g)	85.100	97.660	102.460	0.600
Pod weight/plant (g)	34.470	36.560	40.080	0.850
No of Branches/plant	2.250	3.060	3.690	0.180
No of Leaves/plant	12.880	13.810	14.250	0.210
No of pods/plant	35.750	37.880	41.190	0.560
No of seeds/ pod	6.070	7.500	7.810	0.430
100 seed weight (g)	5.930	6.380	6.950	0.100
Seed yield/plant (g)	14.160	16.020	20.530	0.860
Seed yield (ton ha^{-1})	1.315	1.400	1.425	0.032
Straw yield (ton ha^{-1})	5.005	5.420	5.765	0.266
Biological yield (ton ha^{-1})	5.895	6.720	7.058	0.200
Protein %	23.320	23.560	24.580	ns
Protein Yield (ton ha^{-1})	0.308	0.332	0.351	0.006
Harvest index %	21.520	21.010	20.240	0.450

plants to naphthalene acetamide (NAD) with different levels led to significant increase in all studied traits in comparison with the control. The exogenous application of naphthalene acetamide (NAD) treatments at (30 and 60 mg L^{-1}) gradually increased significantly ($P<0.05$) by increasing naphthalene acetamide (NAD) concentration from (0.00 to 60 mg L^{-1}) in most of studied characteristics. Results presented in Table (2) show the growth, yield and its related characteristics, protein % and protein yield of mungbean plants responded significantly to both naphthalene acetamide (NAD) treatments compared with the control. Maximum seed yield (1.425 ton ha^{-1}) and protein yield (0.351 ton ha^{-1}) were obtained by the highest foliar application level of naphthalene acetamide (60 mg L^{-1}). These increases were due to the increase in all studied traits except harvest index and Protein % are not reaching to significant level. Additionally, the data also, indicate that the foliar application with naphthalene acetamide at (60 mg L^{-1}) increased seed yield/plant by 44.99 %, biological yield/plant (g) by 20.4 %,number of branches/ plant by 64 %, number of seeds/ pod by 28.67 %, pod weight/plant (g) by 16.28 %, number of pods/plant by 15.22% and 100-seed weight (g) by 17.2% compared to the control treatment. These obtained results are in agreement with those obtained by Foysalkabir *et al.* [15], they found that the maximum 1000-seed weight, seed yield and harvest index were found when mungbean was treated with 40 ppm NAA. Foliar application of NAA has also found to increase plant height, number of leaves per plant, fruit size with consequent enhancement in seed yield in different crops [14]. In addition, the promoting effect of IAA may be attributed to enlarging leaves and increasing photosynthetic activities [27], increasing cell division and accumulation of building units accompanied by greater polysaccharides and total carbohydrates content [28]. IAA and/GA_3 treatments significantly increased total carbohydrate, protein, and nitrogen contents in the yielded seeds of the mungbean plant compared with the control plants. Treatment of 50 mg L^{-1} IAA + 50 mg L^{-1} GA_3 was the most effective treatment as it caused the highest total carbohydrate and protein contents of the seed yield of mungbean [13].

Effect of Interaction Between Naphthalene Acetamide (NAD) and Mungbean Varieties: Data in (Table 3) indicate that the interaction between naphthalene acetamide (NAD) and mungbean genotypes caused significant increase in seed and protein yields and yield attributes (plant height, pods no./plant, pods wt./plant, seeds no./pod, seed yield/plant, straw, and biological yield^{-1}) of mungbean. Furthermore, the highest values of seed yield and protein yield (1.610 and 0.417 ton ha^{-1}) were obtained from the interaction between L20 genotype

Table 3: Effect of interaction between naphthalene acetamide (NAD) treatments on growth, seed yield and its related traits and protein content of some mungbean varieties in sandy soil. (Combined data over two seasons 2022 and 2023)

Genotypes	Treatments	Plant height (cm)	Biological yield/plant (g)	Pod yield/ plant (g)	No. of Branches /plant	No. of Leaves/ plant	No. of Pods/ plant	No. of Seeds/ pod	100 Seed weight	Seed yield/ plant (g)	Seed yield ton ha^{-1}	Straw yield ton ha^{-1}	Biological yield ton ha^{-1}	Protein %	Protein Yield ton ha^{-1}	Harvest index %
D1	0.0	58.00	79.53	30.93	2.00	11.50	34.00	6.50	5.41	12.61	1.33	4.41	5.74	24.36	0.324	23.17
	30	62.50	80.69	33.59	2.50	12.25	36.00	7.50	5.81	15.43	1.35	4.49	5.84	24.71	0.334	23.12
	60	65.00	80.77	36.50	2.75	12.50	40.25	7.75	6.19	19.14	1.38	4.86	6.24	24.78	0.342	22.12
L12	0.0	64.50	85.80	36.46	1.50	13.25	41.00	6.25	5.81	17.16	1.33	5.65	6.98	22.80	0.303	19.05
	30	65.25	89.96	36.60	3.50	13.50	41.50	6.75	6.57	18.93	1.37	6.22	7.59	22.91	0.314	18.05
	60	68.25	97.31	41.37	4.50	14.25	42.00	7.00	7.27	20.27	1.38	6.36	7.74	23.28	0.321	17.83
L20	0.0	63.75	87.86	36.36	3.50	13.50	33.75	6.51	6.20	16.08	1.46	3.66	5.12	25.37	0.370	28.52
	30	65.50	127.58	40.89	3.75	15.25	35.50	7.25	6.28	17.12	1.58	4.43	6.01	25.57	0.404	26.29
	60	78.00	127.83	42.99	4.00	16.00	40.50	8.00	6.88	18.27	1.61	4.80	6.41	25.88	0.417	25.12
L30	0.0	55.50	87.22	34.14	2.00	13.25	34.25	5.00	6.28	10.78	1.14	4.60	5.74	20.73	0.236	19.86
	30	64.25	92.39	35.16	2.50	14.25	38.50	8.50	6.85	12.61	1.30	6.14	7.44	21.06	0.274	17.47
	60	76.25	103.94	39.47	3.50	14.25	42.00	8.50	7.44	24.42	1.33	6.51	7.84	24.36	0.324	16.96
LSD $_{0.05}$		1.59	1.20	1.69	0.35	0.42	1.11	0.85	0.22	1.06	0.07	0.441	0.41	0.41	0.013	0.90

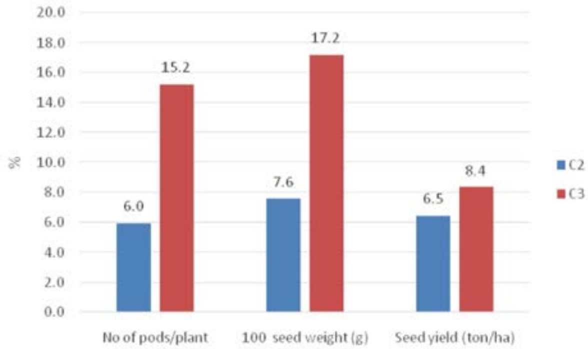

Fig. 1: Effect of Naphthalene Acetamide concentration on some mungbean yield traits increase % compared with the untreated control (C1, C2:30 and 60 mg L^{-1})

and the foliar application of naphthalene acetamide at rate of (60 mg L^{-1}). These increases were due to the increase in plant height (cm), biological yield/plant (g), pod yield/plant (g), no. of leaves/plant, no. of seeds/ pod and protein %compared to the other interactions. The increases in in yield attributes could be attributed to the promotive effect of naphthalene acetamide (NAD)on plant growth and may be to the increases in endogenous phytohormones, which could be lead to increase in photo-assimilates and greater transfer of assimilates to the seeds. In this concern, similar results were reported that significantly influenced by the application of NAA in mungbean, [29] found that the highest seed yield with 20 ppm NAA application can be attributed to more value for the number of pods per plant (25.1), seeds per pod (7.0) and test weight (37.1 g) as compared to other treatments [30].

Beneficial Role of Naphthalene Acetamide on Some Main Yield Traits: From Fig. 1 , it is clear that foliar application of Naphthalene Acetamide regardless variety indicated the clear response of mungbean genotypes which reflected on pod setting, seed index and seed yield ton ha^{-1}. Generally, using the higher concentration (60 mg L^{-1}) surpassed the lower one in percent of increase compared with the untreated control. The percentage increase over the untreated control for the traits No. of pods/plant, 100-seeds weight and seed yield^{-1} were 6, 7.6 and 6.5 when mungbean was sprayed with 30 mg L^{-1} for the 3 traits, respectively while the corresponding increases for the same traits were 15.2, 17.2 and 8.4% compared with the untreated control.

Regarding the results of the interaction (genotype x Naphthalene Acetamide) in comparison with the main

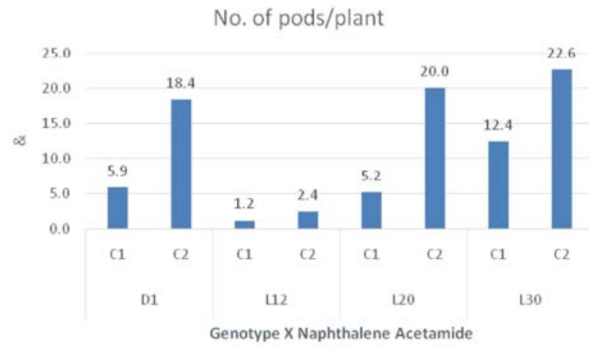

Fig. 2a: Effect of the interaction (genotype X Naphthalene Acetamide concentration on No. of pods/plant increase % compared with the untreated control (C1, C2:30 and 60 mg L^{-1})

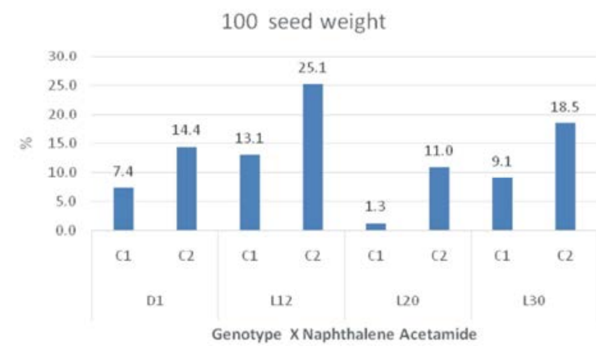

Fig. 2b: Effect of the interaction (genotype X Naphthalene Acetamide concentration on 100-seed weight increase % compared with the untreated control (C1, C2:30 and 60 mg L^{-1})

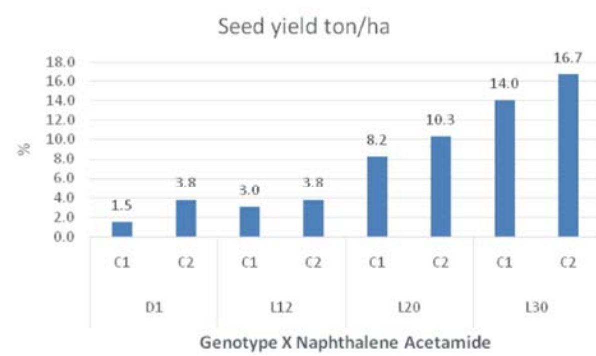

Fig. 2c: Effect of the interaction (genotype X Naphthalene Acetamide concentration on seed yield ton ha^{-1} increase %compared with the untreated control (C1, C2:30 and 60 mg L^{-1})

effect of Naphthalene Acetamide it is worthy to not that each factor do not act independently. The increase % of the three yield trials abovementioned was maximized as shown in Figs. 2a,b and c .

CONCLUSION

It could be concluded from this study that mung bean large seeds genotypes varied in their performance under sandy soil conditions and L20 genotype was superior in the agronomic traits studied than the other tested genotypes. The study revealed that both factors of study (genotypes and folia rnaphthalene acetamide application) do not act independently, where greater yields were achieved through the interaction of both factors of study.

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