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The Effect of Nitrogen and Moisture Superabsorbent on the Yield, Biological Traits, and Nitrogen Percentage in the Pumpkin seeds

Mostafa Amjadian[1#], Mohsen Jahan[1*] and Kamal Hajmohammadnia Ghalibaf[1]

[1]Department of Agrotechnology, Ferdowsi University of Mashhad, Mashhad, Iran.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study investigates the effect of nitrogen and moisture superabsorbent on yield, yield components, seed nitrogen and biological traits in the field of pumpkin during two cropping years (2018-2019) in Kermanshah, Iran. The experiment was carried out as a split-plot based on Randomized Complete Block Design (RBCD) with three replications. The main plot factor was the application of moisture superabsorbent at various levels of 0 (control), 40, 80, 120 kg ha-1, respectively, and nitrogen fertilization at the levels of 0, 50, 100 and 150 kg ha-1 were considered as sub-factor. Results show that treatments significantly affected fruit fresh weight, fruit dry weight, leaf dry weight, stem dry weight, fruit number per plant, grain weight, grain number per fruit, grain nitrogen percentage, except for fruit number per plant. In the most traits, there was an increasing trend when nitrogen levels increased, although N_2 levels of 100 and 150 kg ha^{-1} were not significantly different. In addition, increasing the moisture superabsorbent enhanced the mentioned traits. As a result, the combination of nitrogen 100 and superabsorbent 120 is the best and most economical combination.

**Corresponding author: E-mail: jahan@um.ac.ir;*
[#]Ph.D Student

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1. INTRODUCTION

For centuries, people have utilized medicinal plants to alleviate their pain and heal wounds as a natural gift. As the adverse effects of chemical drugs were identified gradually, the medicinal plants attracted more attention, that increased use of these herbs (Omidbeigi, 2000). Field pumpkin (*Cucurbita pepo* L.) is a valuable medicinal plant in the most developed countries that there are many uses for its seed oil both in traditional and modern medicine [1,2]. The use of superabsorbent in the soil is an effective method that helps to save water [3]. Researchers confirm that superabsorbent can preserve moisture and nutrients in soil as well. Under these conditions, the plant will face water and nutrient deficiencies with less probability [4] Under similar conditions, increased yields have been reported in arid and semi-arid regions [5].

Nitrogen is one of the most effective elements for improving both the quantitative and qualitative yield of medicinal plants [6]. The fresh weight of pumpkin fruit with 2.61 kg on average, 1000 seeds weight (160.36 grams), high fruit yield (12.700 tons) and seed yield with 1.51 tons per hectare using 200 kg nitrogen per hectare was reported

Gholipouri and Hamaran [7], Arvai [8] investigated on the effect of different levels of nitrogen on field pumpkin, and reported that the application of 75 kg N_2 (in Ammonium Nitrate form) caused the highest fruit yield, while increased level of nitrogen reduced fruit yield to 150 kg and did not produce much fruit in two years. Arvai [8] and Sevider et al. [9] have explained that a decrease in fruit yield can be attributed to an abundance of foliage due to increased N_2 fertilization, which causes young foliage to act as a strong sink and absorb nutrients produced in photosynthesis, resulting in the disturbance of vegetative bud's differentiation into a reproductive stage; and ultimately, not fruiting. Conversely, Aghaei and Ehsanzadeh, [10] stated that increasing nitrogen levels reduced fruit number, fruit and grain yield in plants. Similarly, Majidian et al. [11] observed that nitrogen consumption increased yield and water use efficiency of maize plants. Hamzai and Babaei [12] stated that increasing nitrogen application up to 180 kg ha^{-1} enhanced grain yield in field pumpkin. Usually, the highest level of fertilizer efficiency is obtained by absorbing the first nitrogen unit, and nitrogen efficiency decreases with increasing levels of nitrogen [13] Superabsorbent increases soil moisture and nutrient reserves leading to increased growth and yield of plants under water stress [14]. The combination of superabsorbent polymers and balanced consumption of chemical fertilizers (fertilization according to soil test results) and bio-fertilizers led to the highest yield compared to other treatments. Superabsorbent polymers can absorb water from irrigation, prevent deep subsidence and increase water use efficiency. Researches have shown that these compounds improve yield and yield components in corn via retaining water under drought stress and increase the qualitative and growth indices in *chrysanthemum* [15]. Considering the shortage of water resources and the nitrogen fertilizer effect on the medicinal plant's yield, this study aimed to investigate the effects of moisture superabsorbent and nitrogen fertilizer on yield and yield components of field pumpkin across two cropping years.

2. MATERIALS AND METHODS

This study was performed to investigate the effect of different levels of nitrogen fertilizer and moisture superabsorbent on yield and yield components in the field pumpkin seedlings, during two cropping years (2018-2019) in the research field in Kermanshah, Iran. Its geographical coordinates are between 36 and 33 degrees and 15 and 35 degrees north and 24 and 45 degrees to 30 and 48 degrees' east longitude. The experiment was carried out as a split-plot in the randomized complete block design (RCBD) with three replications. Experimental treatments were consisted of four moisture superabsorbent levels (0, 40, 80, 160 kg ha^{-1}) as the main factor and four N_2 levels in the form of Urea (0, 50, 100, 150 $kgha^{-1}$) as a sub-factor. In early June, after field preparation operations, such as plowing, disking, and applying superabsorbent, manual sowing of seeds was conducted in bulks. The length of planting rows, seed spacing, and the distance between rows were 5m, 40cm, and 4m, respectively. Distance between the plot and block was one meter as corridor. The plants were thinned manually to achieve their appropriate density, at the 4-leaf stage. Weeds also were controlled manually. The measured traits were fruit fresh weight and dry weight, leaf dry weight, stem dry weight, fruits number, grain weight, grain number per fruit, number of grains per fruit, and grain nitrogen. The Kjeldahl digestion method has been applied to determine of nitrogen. Statistical analysis has been done by SPSS software. Different combination of nitrogen and superabsorbent for explaining the figures is illustrated in Table 1.

3. RESULTS AND DISCUSSION

3.1 Analysis of Variance

Analysis of variance for different traits has been revealed in Table 2. There were significant differences between all traits for superabsorbent and nitrogen, except fruit number per plant. Results demonstrated that superabsorbent, nitrogen and their interaction affected the fresh weight of fruits, fruit dry weight, leaf dry weight, stem dry weight, grain weight and grain nitrogen percentage significantly over a period of two years. Mean comparison was carried out for the traits. Comparison results for each trait are shown in Figs. 1 to 8.

3.2 Fruit Fresh Weight

The comparison of fruit fresh weight was showed on the Fig.1. The co-application of 120 kg ha^{-1} superabsorbent and 150 $kgha^{-1}$ N_2 resulted in the highest average fresh weight while, the lowest one was related to control treatment, so that this treatment indicated an approximately 57% increase compared to the control. According to the results, at different levels of superabsorbent, this trait increased with enhancing consumed nitrogen. The primary reason for this rise could be the availability of moisture provided by increasing the consumption of superabsorbent and improving the amount of available N_2 to the plant, leading to increased vegetative growth, and ultimately, higher fresh fruit weight.

Additionally, there was no significant effect between the interaction impact of 40 and 80 $kgha^{-1}$ superabsorbent and 100 and 150 $kgha^{-1}$ of N_2 treatments in terms of this trait. Higher fresh weight and greater consumption of both N_2 and moisture superabsorbent may indicate the availability of moisture and nitrogen since N_2 is the main nutrient necessary for vegetative growth, which results in higher fresh weight (Fig. 1). Similarly, Gholipouri et al. and Arvai [8] stated that by increasing the consumed N_2 in the field pumpkin, the fruit fresh weight increased.

3.3 Fruit Dry Weight

The comparison of fruit dry weight was showed on the Fig. 2. According to the results, superabsorbent, nitrogen and their interaction significantly affected fruit dry weight (Table 2). There was a maximum average of this trait in the interaction effect of 120 kg ha-1 superabsorbent and 150 kg ha-1 nitrogen treatment, whereas the lowest one was achieved in the control treatment, so that this treatment increased about 73% compared to the control. Results revealed that with different levels of superabsorbent along with increased nitrogen, the dry weight of the fruit was enhanced. Moreover, there was no significant difference between the interaction effect of control, 40, and 80 kg ha^{-1} of superabsorbent and 50, 100, and 150 $kgha^{-1}$ of nitrogen treatments (Fig. 2). In the same vein, Qolipouri et al. and Aroy found that increasing nitrogen consumption on the field pumpkin led to increased fresh weight and biomass in the fruits.

3.4 Leaf Dry Weight

The comparison of leaf dry weight was showed on the Fig. 3. Results revealed that superabsorbent, nitrogen and their interaction had a significant effect on leaf dry weight (Table 2). Co-application of 120 $kgha^{-1}$ superabsorbent and 150 $kgha^{-1}$ N_2 recorded the highest leaf dry weight by so that this trait increased nearly 91% compared to the control. With increasing superabsorbent and nitrogen consumption, leaf dry weight has increased. It might be explained by an increase in the biomass of a plant due to the consumption of N2 and the availability of moisture (Fig. 3). Aghaie and Ehsanzadeh also found similar results.

3.5 Stem Dry Weight

The comparison of stem dry weight was showed on the Fig.4. Superabsorbent, N_2 treatment and their interaction significantly affected stem dry weight during two years of experiments (Table 2). The highest and lowest values of this trait were associated with the application of 120 $kgha^{-1}$ superabsorbent and 150 $kgha^{-1}$ pure N_2, our findings confirm that vegetative growth was directly associated with the use of N_2 and superabsorbent. Additionally, this plant's extensive vegetative growth was stimulated and enhanced by favorable environmental conditions resulted in the maximum dry stem biomass when high N2 consumption and superabsorbent were used (Fig. 5). Rabiei and Tousi-e-Cohl (2011) reported similar results.

Table 1. Different combination of nitrogen and superabsorbent

1	Nitrogen 0 + Super Adsorbent 0	9	Nitrogen 100 + Super Adsorbent 0
2	Nitrogen 0 + Super Adsorbent40	10	Nitrogen 100 + Super Adsorbent 40
3	Nitrogen 0 + Super Adsorbent 80	11	Nitrogen 100+ Super Adsorbent 80
4	Nitrogen 0 + Super Adsorbent 120	12	Nitrogen 100+ Super Adsorbent 120
5	Nitrogen 50 + Super Adsorbent 0	13	Nitrogen 150 + Super Adsorbent 0
6	Nitrogen 50 + Super Adsorbent 40	14	Nitrogen 150 + Super Adsorbent 40
7	Nitrogen 50 + Super Adsorbent 80	15	Nitrogen 150 + Super Adsorbent 80
8	Nitrogen 50 + Super Adsorbent 120	16	Nitrogen 150 + Super Adsorbent 120

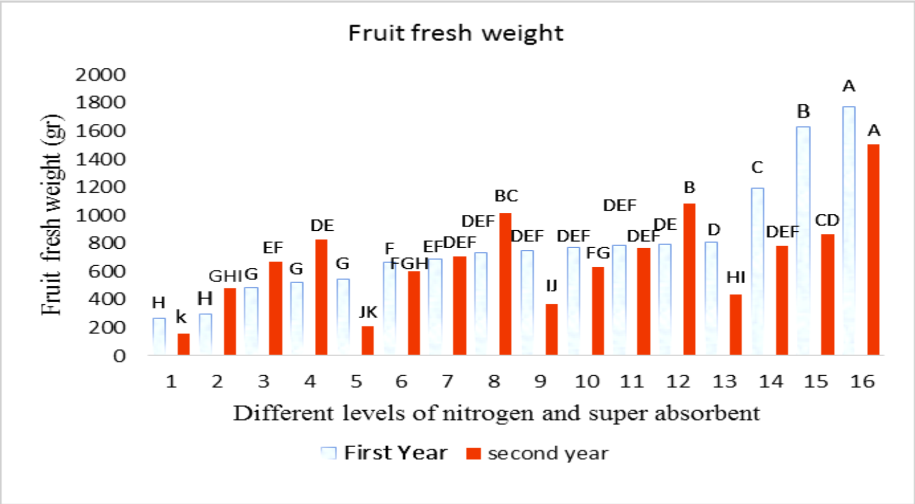

Fig. 1. Comparison of fruit fresh weight
(Means followed by the same letters in each column are not significantly different (Duncan multiple range test at 5% probability level)

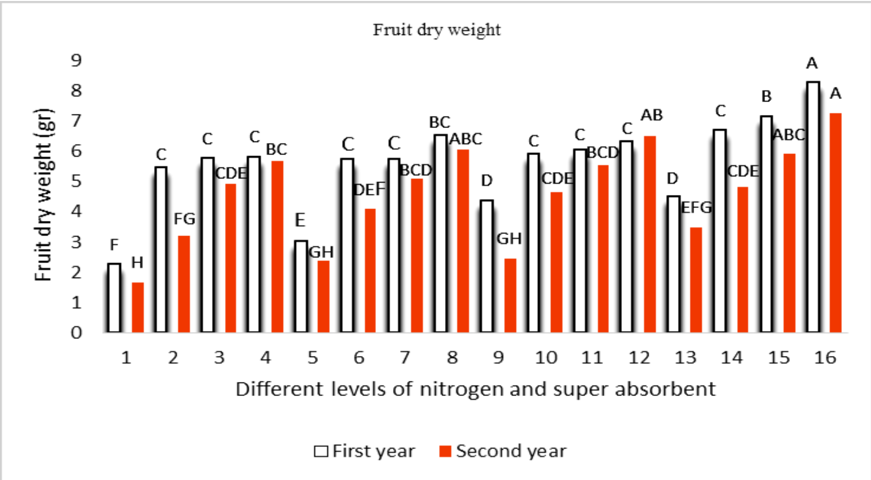

Fig. 2. Fruit dry weight
(Means followed by the same letters in each column are not significantly different (Duncan multiple range test at 5% probability level)

Table 2. Analysis of variance of measured traits for the first Year

S.O.V.	Fruit Fresh weight	Fruit dry weight	Leaf dry weight	Stem dry weight	Fruit number per plant	Grain weight	Grain number per fruit	Grain nitrogen percentage
Replication	1.44	43719.56	20379.34	5876.15	0.06	599.91	1907.65	0.015
Superabsorbent	3.119*	197776.2**	560859.438**	351883.319**	2.243ns	516592.477**	43906.743**	0.227ns
Error1	0.56	44015	8215.46	4513.91	0.7	551.91	8072.87	0.0001
Nitrogen	5.288*	323448.746**	2696.619**	38015.64**	1.632ns	48246.026**	86032.576**	1.1**
N*S	8.249*	106970.921**	7752.652**	2064.321**	4.706ns	12355.43**	122577.428**	0.1**
Error2	1.40	3868.96	1810.12	771.67	1.04	2110.92	8262.84	0.01
CV.	21.11	7.84	13.19	10.43	21.21	13.91	13.18	13.91

** and ** mean significant at 5% and 1% probability, respectively. ns means non-significant*

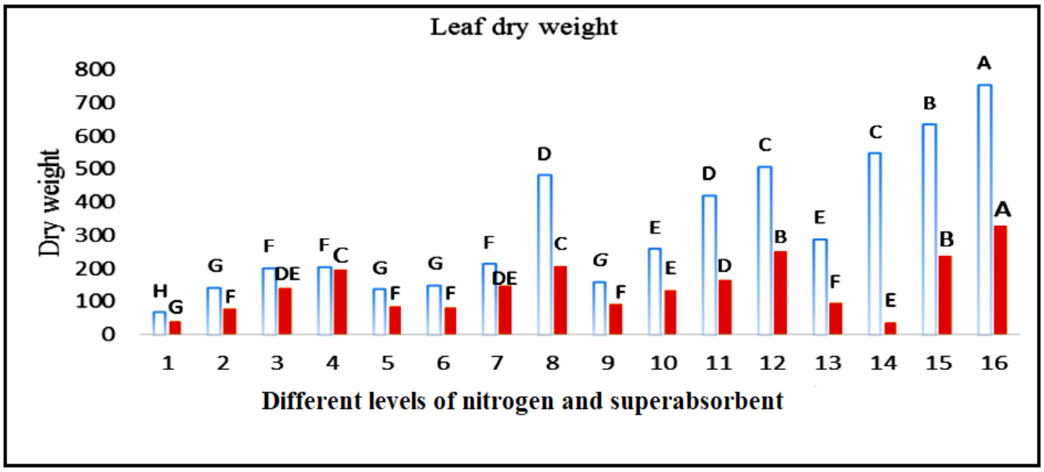

Fig. 3. Leaf dry weight

(Means followed by the same letters in each column are not significantly different (Duncan multiple range test at 5% probability level)

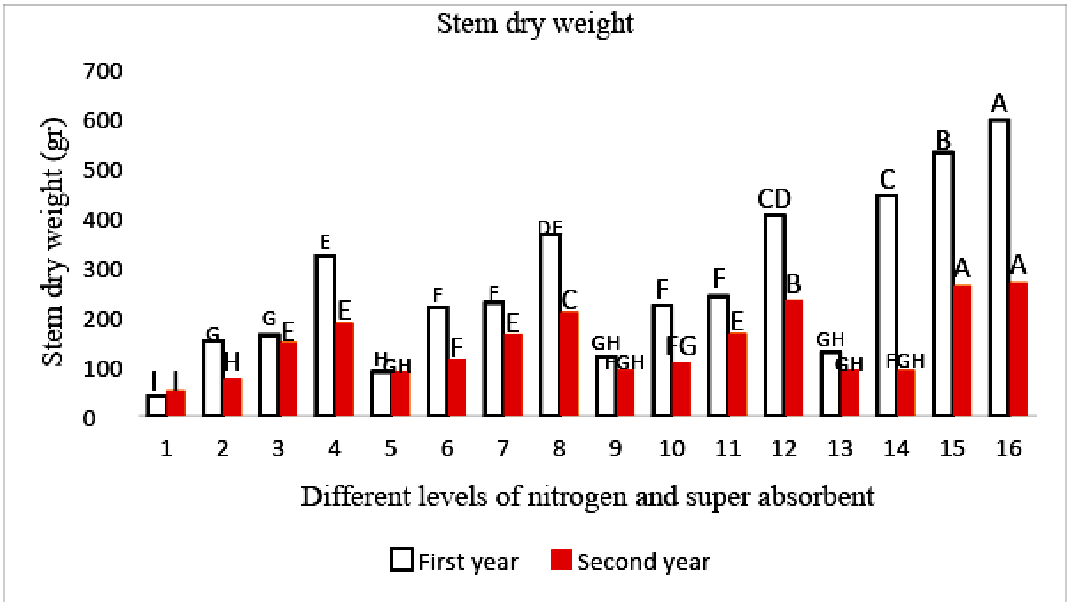

Fig. 4. Stem dry weight

Means followed by the same letters in each column are not significantly different (Duncan multiple range test at 5% probability level)

3.6 Fruit Number Per Plant

The main effects of superabsorbent and nitrogen on fruit number per plant were not significant in the first year of the experiment, while their main and interaction effects were significant in the second year. The highest average of this trait across two-year experiment was recorded for the treatment of 150 kg ha^{-1} N_2 and 120 kg ha^{-1} superabsorbent, while 50, 100 and 150 kg ha^{-1} nitrogen treatments were not significantly different. The lowest fruit number was recorded in control treatment. In addition, it is notable that the difference between 100 and 150 kg ha^{-1} of N2 application at various levels of superabsorbent was not significant during two years of experiment. Considering that the number of fruits per plant was not impacted by nitrogen consumption and superabsorbent, it can be claimed that this trait is largely influenced by its specific genetic pattern and does not respond greatly to environmental conditions (Fig. 6). Fazeli Rostampour et al. also reported similar results in their studies.

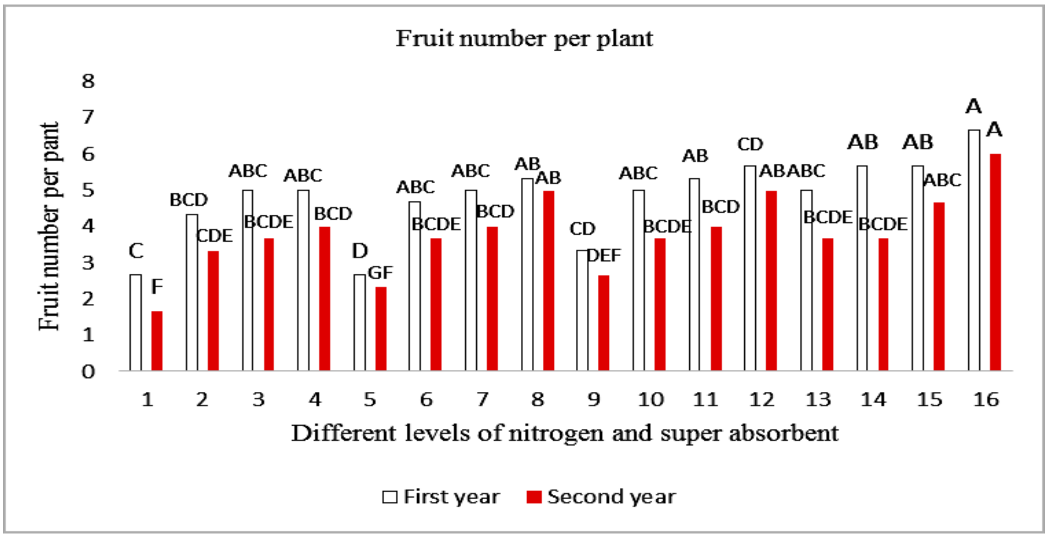

Fig. 5. Fruit number per plant

Means followed by the same letters in each column are not significantly different (Duncan multiple range test at 5% probability level)

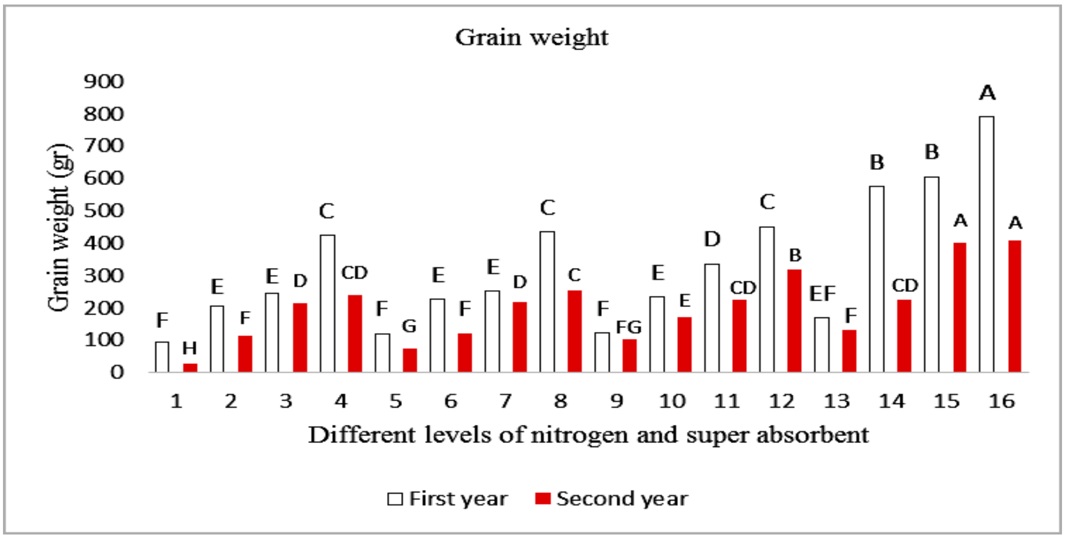

Fig 6. Grain weight

(Means followed by the same letters in each column are not significantly different (Duncan multiple range test at 5% probability level)

3.7 Grain Weight

Results illustrated there was a significant effect of superabsorbent, N_2, and interaction of these two factors on grain weight during two years of experiment (Table 2). Mean comparison results illustrated that the highest grain weight was related to N_2 application of 150 kgha^{-1}, and 120 kgha^{-1} of superabsorbent, while the lowest one, was achieved in the control treatment. This phenomenon could be explained by increasing seed storage simultaneously with higher consumption of nitrogen and superabsorbent (Fig 6). Hamzai and Babaei (2013) also stated similar results on pumpkin parchment.

3.8 Grain Number Per Fruit

Superabsorbent, N_2 treatment and their interaction significantly affected grain number per fruit across both years of experiments (Table 2). Mean comparison results of this trait showed that during both years the highest number of grains per fruit was associated with N_2 application at 150 kgha^{-1}, and 120 kgha^{-1} of superabsorbent (Fig. 7).

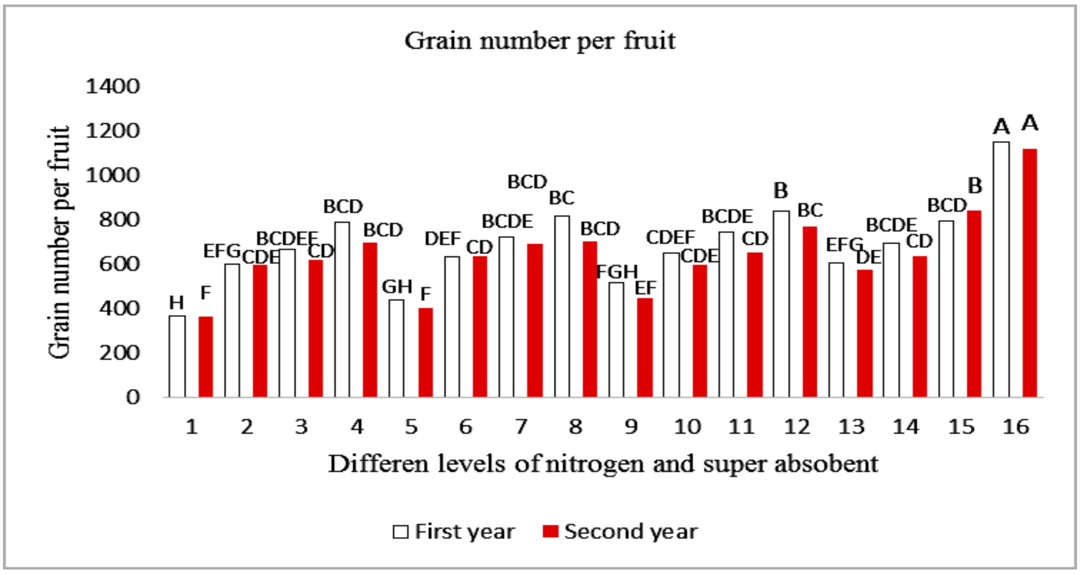

Fig. 7. Comparison of grain number per fruit

(Means followed by the same letters in each column are not significantly different (Duncan multiple range test at 5% probability level)

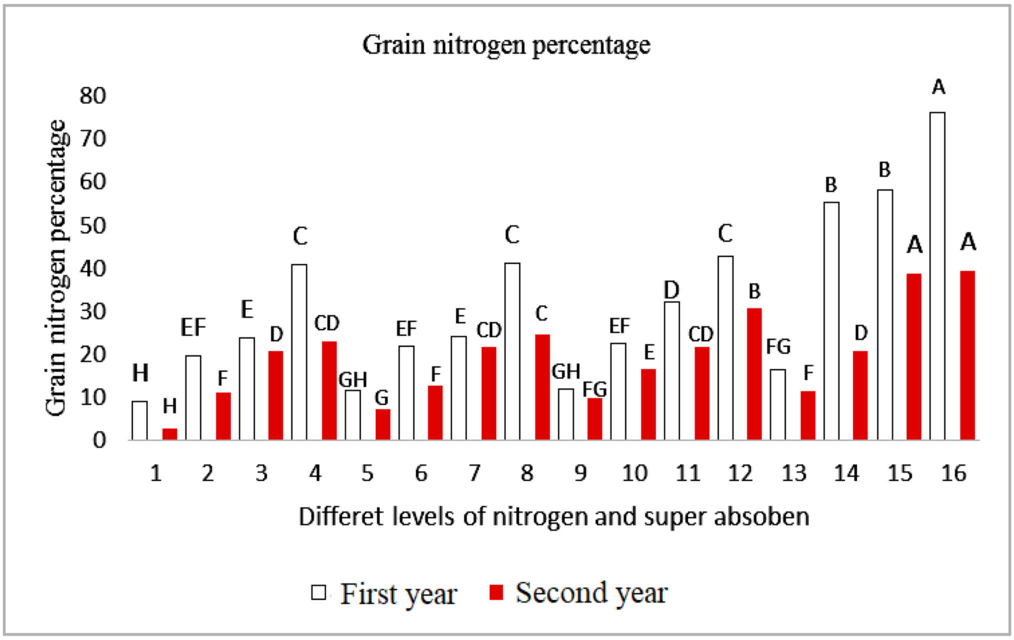

Fig. 8. Comparison of grain nitrogen percentage

(Means followed by the same letters in each column are not significantly different (Duncan multiple range test at 5% probability level)

3.9 Grain Nitrogen Percentage

Results revealed that superabsorbent and nitrogen had a significant effect on grain nitrogen percentage (Table 2.). Mean comparison results of this trait explained that the maximum grain nitrogen percentage was recorded in 150 kg ha-1 of nitrogen and 120 kgha^{-1} of superabsorbent treatment, whereas the control treatment illustrated the lowest one. In addition to increasing nitrogen consumption, some of it may be absorbed and stored in the seeds, thus increasing the percentage of nitrogen in the seeds (Fig. 8). Similar results were observed by Dragasevic et. al.

4. CONCLUSION

The importance of medicinal plants in human life today is important and clear. But it is very important to tame and mass produce the amount of medicinal plants and the effect of agronomical factors to increase yield production. Among the factors affecting production, the amount of moisture and nitrogen play an important role. Today, moisture superabsorbent materials play an important role in water absorption. The interaction of moisture and the amount of nitrogen plays a key role in the plant yield production. In this study, the combination of nitrogen 150 + superabsorbent 120 increased the yield of pumpkin. Which was made available to farmers and researchers as a novel achievement. Of course, there is no significant difference between the concentration of nitrogen 100 and 150 kg^{-1}. As a result, the combination of nitrogen 100 and superabsorbent 120 is the best and most economical combination.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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