Research Article

Seed priming with iron and zinc improves growth and yield of groundnut (*Arachis hypogaea* L.)

Tahir Amir Khan^{1*}, Zammurad Iqbal Ahmed², Sairah Syed³, Abdullah Baloch¹, Muhammad Naveed Malik², Muhammad Irfan², Waqas Ahmad⁴, Abdul Latif¹, Zulfiqar Ali Rahujo⁵ and Sumeria Muhammad Hussain⁴

1. Balochistan Agricultural Research & Development Centre, Quetta-Pakistan

2. Department of Agronomy, PMAS-Arid Agriculture University Rawalpindi-Pakistan

3. Directorate of Agronomic Research, Ayub Agriculture Research Institute Faisalabad-Pakistan

4. National Agricultural Research Centre, Islamabad-Pakistan

5. Agricultural Research Institute, Jaffarabad-Pakistan

*Corresponding author's email: info.maliktahir@gmail.com

Citation

Tahir Amir Khan, Zammurad Iqbal Ahmed, Sairah Syed, Abdullah Baloch, Muhammad Naveed Malik, Muhammad Irfan, Waqas Ahmad, Abdul Latif, Zulfiqar Ali Rahujo and Sumeria Muhammad Hussain. Seed priming with iron and zinc improves growth and yield of groundnut (*Arachis hypogaea* L.). Pure and Applied Biology. Vol. 6, Issue 2, pp553-560. <http://dx.doi.org/10.19045/bspab.2017.60057>

Received: 13/01/2017

Revised: 08/04/2017

Accepted: 13/04/2017

Online First: 18/04/2017

Abstract

Seed priming is considered as an important component that results in early establishment of crop seedling. Thus, the effect of seed priming with iron (Fe) and zinc (Zn) on growth and yield components of groundnut (cv. BARI-2011) was evaluated by using different doses of Fe (0.1% and 0.3%) and Zn (0.5% and 1.0%) in RCBD design with two factors factorial arrangement having three replications. The crop was grown in April, 2016 at the Research Farm of PMAS-Arid Agriculture University, Rawalpindi, (Pothohar Plateau) Punjab, Pakistan. Data revealed that plant height and number of plants were highest at 0.3% Fe in combination with 1.0% Zn. Similarly, numerical values for all measured yield components i.e., number of pods plant⁻¹, kernel weight (kg ha⁻¹), 100 kernel weight (g), pod yield (kg ha⁻¹), biological yield (kg ha⁻¹), harvest index (HI) and shelling percentage were significantly higher at 0.3% Fe in combination with 1.0% Zn as compared to the control. The control plot resulted in the lowest values for all the parameters studied. It can be inferred from the results that seed priming at the rate of 0.3% Fe in combination with 1% Zn is recommended for obtaining higher yield of groundnut.

Keywords: Micronutrients; Seed priming; BARI-2011; Kernel; Pothohar tract

Introduction

Groundnut (*Arachis hypogaea* L.) is the fourth-largest oilseed crop in the world, cultivated in more than 100 countries [1]. Worldwide, it is cultivated on 25.41 million

hectares whereas the share of Pakistan is 0.0938 million hectares [2]. Groundnut is used for direct consumption, in confectionary industry and as a vegetable oil for cooking. Moreover, groundnut restores

nitrogen into the soil by fixing it without upsetting non-renewable resources or disturbing balance in the environment and thus is considered as one of the most important legume crop [3]. In Pakistan, groundnut is grown mainly in rainfed areas. In 2011-12, out of total peanut cultivated area, about 91% lies in Punjab, 8% in Khyber Pakhtun khwa (KPK), and 1% in Sindh [4]. About 85% of total area under groundnut cultivation in Punjab lies in the Pothowar tract, producing 71% of the country's total production [5]. Among other factors, micronutrient deficiency is an important factor for low crop productivity of groundnut in these areas. Zinc plays a vital role in the germination and crop growth [6, 7] but overall Pakistani soils are deficient in micronutrients, especially in Zinc, Iron and Copper [8].

Due to the calcareous nature of soils, in many arid areas, alkaline pH, poor organic matter status, salinity, drought stress and improper utilization of fertilizer, deficiency of micronutrients is a common problem in plants, [9, 10] therefore, the combined use of macro and micro nutrients is very important for increasing the crop production [11]. Micronutrients are vital for various physiological processes such as photosynthesis, respiration, cell elongation, cell maturation, development of meristematic tissue and formation of protein [12]. Among micronutrients, Zn deficiency affects the productivity of groundnut, [13] negatively influencing the quality and yield components of grain. Beside Zn, Fe is essential for all living beings and indispensable for various activities [14]. It is a vital part of many proteins and plant pigments [15]. Though iron is sufficiently present in most soils, but not in the forms available to plants *i.e.* ferric form [16].

In crop plants, seed invigoration is a broader term and has been used in two different ways, *i.e.*, seed priming and foliar

application [17]. Seed priming improves the germination speed [18], minimizes the time between sowing and emergence, enhances seedling emergence and vigor, crop establishment and uplift yield [19-21]. Nutri-priming technique is considered to be an efficient way from economic point of view as it uses low doses of micronutrients and is easy to operate. It also facilitates the vigorous germination and seedling emergence, better stand establishment and crop growth [22].

In the light of the importance of micronutrients, the main objective of the present study was to evaluate the effects of seed priming with micronutrients *i.e.* iron and zinc on the growth, yield and yield components of groundnut.

Materials and methods

The study was carried out to determine the effects of seed priming with Fe and Zn on the growth and yield of groundnut from April to October, 2016 at University Research Farm (33.11° N latitude to 73.01° E longitude), Chakwaal Road, PMAS- Arid Agriculture University, Rawalpindi (Pothwar pleatue), Punjab, Pakistan. The climate of the region is semi-arid with annual rainfall of 850 mm and soil of the farm varies from sandy loam to loam in texture with pH ranging from 7.7 to 7.8. An approved variety of groundnut (*cv.* BARI-2011) was used. The seeds of groundnut were obtained from National Agricultural Research Center, Islamabad, Pakistan. The seeds were sown using hand drill in rows at a depth of 2-3 cm from the soil surface. Row-row and plant-plant distance was maintained at 45 and 10 cm, respectively. The experiment was laid out in a Randomized Complete Block Design (RCBD) with two factors factorial arrangement (Fe and Zn) and replicated three times. The field was divided into 3 blocks, each containing 9 plots of size 3.15 m × 3 m with a total plot size of 330 m².

Three levels of iron, viz. [0 (control), 0.1% and 0.3% solution] and three levels of zinc, viz. [0 (control), 0.5% and 1% solution] were used to treat the groundnut seeds before sowing. Solutions of the required concentrations of Fe and Zn were prepared in 9 beakers and the seeds were soaked in these solutions for 8 hours. Treatment combinations were randomly allocated in each block. Basal dose of fertilizer was applied at the rate of 30-80-30 NPK kg ha⁻¹. The crop was sown only on rain water. No irrigation was given throughout the growing season of the crop.

The studied growth parameters were: number of plants (m⁻²) at maturity, plant height (cm) and yield and yield contributing parameters were: number of pods plant⁻¹, kernel weight (kg ha⁻¹), hundred kernel weight (g), pod yield (kg ha⁻¹), biological yield (kg ha⁻¹), harvest index (HI) and shelling percentage (SP).

Harvest index for each plot was calculated by using the following formula:

$$\text{Harvest Index (HI)} = (\text{Grain Yield} / \text{Biological Yield}) \times 100$$

Shelling percentage for each plot was calculated by dividing the kernel weight (kg ha⁻¹) with pod weight (kg ha⁻¹) and then multiplied by 100. The formula used to calculate shelling percentage was as follows

$$\text{Shelling Percentage (SP)} = (\text{Kernel Weight} / \text{Pod Weight}) \times 100$$

Collected data was subjected to analysis of variance (ANOVA) by Statistics 8.1 and the differences among treatment means were compared by Tukey's honest significant difference test (HSD).

Soil sampling

Soil sampling was done with the help of agar for soil fertility determination before sowing and after harvesting. The samples were collected from 5 randomly selected points from the field at the depth of 15 cm and composite sample was prepared. The analysis was carried out at the Laboratory, Department of Soil Fertility Analysis and Water Status, Rawalpindi, Pakistan for the determination of soil iron and zinc status.

The soil analysis showed that the soil was low in both micronutrients. The levels of iron and zinc in the soil before sowing were 0.83 and 0.56 ppm, respectively. After harvesting, it was observed that the levels of iron and zinc were considerably low i.e., 0.27 and 0.35 ppm, respectively.

Results

Growth parameters

The number of plants and plant height calculated at maturity was significantly affected by the levels of iron while in case of zinc, the effect was significant for number of plants and non-significant for plant height (Figure 1 and 2). It was noticed that the number of plants increased with increase in iron and zinc concentrations. Maximum number of plants (m⁻²) of groundnut was recorded at the highest tested concentrations for both the micronutrients (0.3% Fe and 1% Zn) and the lowest number of plants was found in the control. The data presented in Figure 1 depicted that the plant height responded positively to iron application. The plant height of groundnut was increased with the increase in iron concentrations where taller plants (41.50 cm) of groundnut were recorded at 0.3% Fe and shorter plant height were found in the control i.e., 35.46 cm.

The interaction (Fe × Zn) was significant for number of plants and plant height of groundnut (Table 1). The interaction 0.3% Fe × 1% Zn produced 20 plants m⁻² of groundnut but the effect of Fe was more visible as compared to Zn. Because seed priming with 0.3% Fe resulted in significantly higher number of plants (18.8 m⁻²), compared to seed priming with 1% Zn where number of plants (15.6 m⁻²) was found which was non-significantly higher than the control. The interaction effect of the highest levels of micronutrients (0.3% Fe × 1% Zn) produced the maximum plant height of groundnut, i.e., 42.3 cm that was statistically at par with the interactions 0.3%

Fe, 0.3% Fe $\times$ 0.5% Zn and 0.1% Fe $\times$ 1% Zn (Table 1). The minimum (34.5 cm) plant

height of groundnut was recorded in the control.

Figure 1. Effect of various levels of Fe on the growth parameters of groundnut

Figure 2. Effect of various levels of Zn on the growth parameters of groundnut

Table 1. Interaction effect of various levels of Fe and Zn on the growth parameters of groundnut

Interactions	Number of plants (m ⁻²)	Plant height (cm)
Control	14f	34.5e
0.1% Fe	16.1def	37.2cde
0.3% Fe	18.8abc	40.7abc
0.5% Zn	14.9ef	35.9de
1.0% Zn	15.6def	36.1de
0.1% Fe $\times$ 0.5% Zn	16.7cde	38.1bcde
0.1% Fe $\times$ 1.0% Zn	17.2bcd	39.2abcd
0.3% Fe $\times$ 0.5% Zn	19.2ab	41.5ab
0.3% Fe $\times$ 1.0% Zn	20.a	42.3a

(For No. of Plants) HSD = 5%, Fe = 0.97, Zn = 0.97, Interaction = 2.31

(For Plant Height) HSD = 5%, Fe = 1.75, Zn = 1.75, Interaction = 4.17

Means not sharing a letter in common differ significantly at $P=0.05$

Yield components

The number of pods plant⁻¹, kernel weight, 100 kernel weight, pod yield, biological yield, harvest index and shelling percentage were significantly affected by the levels of iron and zinc (Table 2). It was noticed that yield and all yield components increased by using higher doses of iron and zinc. Maximum values for number of pods (42.7), kernel weight (1715.6 kg ha⁻¹), 100 kernel weight (60.4 g), pod yield (2537.2 kg ha⁻¹), biological yield (7623.9 kg ha⁻¹), harvest

index (22.5 %) and shelling % (67.6) were recorded at 0.3 % Fe level. As compared to the treated plots, control resulted in lower values for all the variables.

The interaction effect of Fe and Zn on the yield and yield components of groundnut was also significant (Table 3). The interaction (0.3% Fe × 1.0% Zn) produced significantly higher pod yield (2603.8 kg ha⁻¹) of groundnut followed by 0.3% Fe × 0.5% Zn. The other interaction was found to be non-significant with each other.

Table 2. Effect of various levels of Fe and Zn on the yield and yield components of groundnut (main effects)

Treatments	No. of Pods plant ⁻¹	Kernel Weight (kg ha ⁻¹)	100 Kernel weight (g)	Pod Yield (kg ha ⁻¹)	Biological Yield (kg ha ⁻¹)	Harvest Index (%)	Shelling %
Fe							
Control	33.2 b	1286.7c	42 c	2186.1c	6702.6c	19.2c	58.9c
0.1%	40.8 a	1469b	49.5 b	2311.2b	7089.6b	20.7b	63.5b
0.3%	42.7 a	1715.6a	60.4 a	2537.2a	7623.9a	22.5a	67.6a
Zn							
Control	36.8b	1419.1c	48c	2282.4b	6968b	20.3c	62c
0.5%	38.7b	1480.7b	50b	2340.4b	7140.8ab	20.7b	63b
1.0%	41.3a	1571.5a	53.9a	2411.6a	7307.45a	21.4a	64.9a

Means not sharing a letter in common differ significantly at $P=0.05$

Table 3. Interaction effect of various levels of Fe and Zn on the yield and yield components of groundnut

Interactions	No. of Pods plant ⁻¹	Kernel Weight (kg ha ⁻¹)	100 Kernel weight (g)	Pod Yield (kg ha ⁻¹)	Biological Yield (kg ha ⁻¹)	Harvest Index (%)	Shelling %
Control	30.5e	1245f	40.5f	2170.8d	6609.5f	18.8g	57.4g
0.1% Fe	38.9bc	1386de	46.4e	2222.1d	6921.3def	20de	62.4ef
0.3% Fe	42.06ab	1626.32bc	56.53bc	2454.36ab	7373.1bc	22.1bc	66.3bc
0.5% Zn	32.8de	1277ef	41.1f	2187d	6693.5ef	19.1fg	58.4g
1.0% Zn	36.4cd	1338.2def	44.5ef	2200.4d	6804.9ef	19.7ef	60.8f
0.1% Fe × 0.5% Zn	41abc	1444.6d	49de	2280.9cd	7081.2cde	20.4d	63.3de
0.1% Fe × 1.0% Zn	41.1abc	1576.3c	53.2cd	2430.5bc	7266.4bcd	21.7c	64.9cd
0.3% Fe × 0.5% Zn	42.28ab	1720.54ab	60.70ab	2553.38ab	7647.8ab	22.5ab	67.4b
0.3% Fe × 1.0% Zn	45.11a	1800.05a	64.00a	2603.83a	7850.7a	22.9a	69.1a

Means not sharing a letter in common differ significantly at $P=0.05$

Discussion

Seed priming governs cellular, sub-cellular and molecular changes in seeds and enhances seed vigor during germination and emergence that resulted in good crop stand and ultimately better growth of crop [23, 24]. In the present study, seed priming with Fe and Zn improved the number of plants, plant height, yield and yield components, suggesting that the seed priming is important for increasing the overall yield of groundnut. Increase in number of pods plant⁻¹ and kernel weight of groundnut may be attributed to Fe which is known to enhance the nitrogenase activity resulting in the better nodule and peg formation thereby boosting the production of number of pods plant⁻¹ [25]. Similarly, kernels of treated plots with Fe and Zn were healthy with vigorous growth and larger in size which resulted in the increase of 100 kernel weight. Whereas, kernels of control plots were smaller due to the stunted growth of plants. These results are in line with Mirshekari *et al.* [26] who reported the positive effects of seed priming with iron and boron on 1000 seed weight of groundnut.

In our study, the highest pod and biological yield of groundnut was noted in Fe and Zn treated plots. This may be attributed to the increased number of pods plant⁻¹ of groundnut due to the seed priming with Fe and Zn. The improvement in the biological yield of groundnut with Fe and Zn may be attributed to seed priming with zinc which is responsible for the better crop emergence, seedling vigor, yield and biomass of the crop [27].

Seed priming with Fe and Zn also showed the better harvest index and shelling percentage as compared to the control. The highest shelling percentage of harvest index with Fe and Zn seed priming might be due to more economic yield, *i.e.*, healthy kernels with no empty pod. Ali and Seyyed [25] presented results which are very close to our

findings that Fe application through seed treatment resulted in the better shelling percentage and harvest index of groundnut crop.

Conclusion

Findings of this study suggests that seed priming with combination of Fe and Zn (0.3% and 1%) resulted in the better growth and yield of groundnut (variety BARI-2011). These research findings have an implication for enhancement of yield of groundnut which can be further implied on other leguminous crops. Moreover, further investigation on higher levels above 0.3% and 1% of Fe and Zn, respectively can be a step forward to identify the highest beneficial levels of Fe and Zn. Finally, these findings will help motivate our farmer to adopt seed priming technique to apply micronutrients like Fe and Zn in more efficient and effective way.

Authors' contributions

Conceived and designed the experiments: TA Khan & ZI Ahmed, Performed the Experiments: TA Khan, MN Malik, M Irfan & W Ahmad, Analyzed the Data: TA Khan & S Syed, Contributed reagents/ materials/ analysis tools: A Baloch, A Latif, ZA Rahujo & SM Hussain, Wrote the paper: TA Khan.

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