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EFFECT OF VARIOUS SOURCES AND DURATIONS OF PRIMING ON SPINACH SEEDS

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Abstract

The present investigation was undertaken to evaluate the effect of priming on spinach with various sources and soaking durations at the Department of Horticulture, Khyber Pukhtunkhwa Agricultural University Peshawar during 2008-09. The experiment was laid down in Randomized Complete Block Design (RCBD) with three replications. Four priming sources (Distilled water, DAP, SSP, SSP+Na_2CO_3) and soaking durations of 4h interval (4h to 24h) along with control were studied. Number of days to emergence, germination percentage, survival percentage, leaf area (cm^2), leaf yield (tons ha^{-1}) and 100 number seeds weight (g) were significantly affected by priming sources and durations. Mean values showed that early emergence (5.952 days), maximum germination percentage (88.14), survival percentage (89.96), plant height (31.24 cm), leaf area (63.12 cm^2), leaf yield (14.667 tons ha^{-1}) and 100 seed weight (1.00 g) were observed in plots in which seeds were soaked in SSP+Na_2CO_3 solution. In case of soaking durations, early emergence (5.917 days), maximum germination percentage (89.42), survival percentage (90.40), plant height (31.16 cm), leaf area (60.72 cm^2), leaf yield (14.340 tons ha^{-1}) and 100 seed weight (0.966 g) were recorded in the plots in which seeds were soaked for 24h. Mean values of interactions results showed that early emergence (5.0 days), maximum germination percentage (95.33), survival percentage (95.38), plant height (33.70 cm), leaf area (70.78 cm^2), leaf yield (16.257 tons ha^{-1}) were observed in plots where seed were soaked in SSP+Na_2CO_3 solution for 24h. Overall SSP+Na_2CO_3 solution proved the best in most of the parameters while distilled water (control) showed comparatively poor performance.

Introduction

Spinach *(Spinacia oleracea* L., family Chenopodiaceae), first cultivated by the Arabs, probably originated in southwest Asia. The Moors (Berbers and of Arab Muslims descent) took it to Spain from where it spreaded throughout the world. Spinach is an annual dioecious plant. It grows rapidly, especially in spells of dry weather with bright sunshine, and has a tendency to bear seed quickly (Malik *et al.,* 1996). Accelerating and homogenizing the germination process is one of the important prerequisites for an established and efficient crop stand and ultimate final yield. This is affected by the water reduction because with increase in drought level, water uptake, germination and seedling growth are inversely decreases (Achakzai, 2011).

The concept of priming is often familiar to farmers but generally they prime only after better sowing conditions have passed or for gap filling. Priming has been a recommended practice but has not widely adopted. In recent years, the use of priming has increased following participatory approach in India, Pakistan and Bangladesh. Many crops are primed before planting. Priming is a water-based process, performed on seeds to increase germination uniformity, and thus enhances vegetable stand establishment. Seed priming is a low cost and low risk intervention, used to overcome poor stand establishment. Seeds are soaked in water before being surface dried to storage moisture. The storage of such primed seeds can result in high germination and seedling emergence rates, vigorous early growth, early flowering, maturity, and higher yields than unprimed seeds. Several methods have been used to precondition seeds as an attempt to improve germination and seedling establishment of many field crops, including wetting and drying, pre-germination and control hydration by means of an osmoticum such as polyethylene glycol. This method of control hydration is called priming or osmo conditioning (Khan *et al.,* 2005).

Among the major nutrients required by the crop, phosphorus is one of the essential nutrients, both as part of several plant structural compounds as well as in the catalysis of numerous fundamental biochemical reactions of plant. Phosphorus has the role in capturing and converting the sun’s energy into useful plant compounds, which illustrates how vital the phosphorus nutrition is for the development and production of normal plant (Hartmann & Geneve, 2000). Plant needs P during the rapid growth period and is a structural component of macromolecules, such as the nucleic acid (DNA and RNA) and ATP. It is associated with root growth and root health, increase tolerance to root-rot, increase fruit quality, creates disease resistance, stimulates growth and gives early maturity. The amount of phosphorus in plants ranges from 0.05% to 0.50% of total dry weight, when seed absorbs phosphorus during soaking, it provides a nutritious environment around germinating embryo providing nutritional support in early phase of crop development (Taylor & Herman, 1998). Seed priming in phosphorus (P) solution is supposed to be an effective way of promoting early germination and seedling growth in P-deficient soils and ensures phosphorus supply through seed soaking, and accumulated up to 56% more biomass than unprimed seedlings (Asgedom &Becker, 2001). DAP was effective in reducing the phytoavailability of Pb and Zn (Khan *et al*., 2013).

Keeping in view the importance of seed priming, the present study was carried out to find out the best priming source, soaking duration and the effect of different sources of phosphorus fertilizer application for early emergence and good quality yield of spinach.

Materials ad Methods

The current study was undertaken at Ornamental Horticulture Nursery the Agricultural University Peshawar in October 2008-09. The experiment was laid out in Randomized Complete Block Design (RCBD) in Split plot arrangement with 28 treatments per replication repeated three times. There were four main plots; each main plot was divided into 7 sub plots. The following two factors were studied in this experiment.

Factor A: The sources for seed soaking were kept in the main plot by using 1% solution.

1. Distilled water (D.W)
2. Diammonium phosphate solution (DAP)
3. Single super phosphate solution (SSP)
4. Single super phosphate solution + Sodium bicarbonate (SSP+Na_2CO_3).

Factor B: Soaking durations, with a difference of 4 hours interval were kept in sub plots. The durations were from 0 to 24 hrs i.e. 0, 4, 8, 12, 16, 20, 24, hrs.

Soil analysis: Before sowing of seeds soil samples up to 20cm depth were taken randomly from different parts of the field and were analyzed in the soil science laboratory at the Agriculture University Peshawar for chemical characteristics.

Chemical characteristics of experimental field

Electric conductivity	0.80ds m^{-1}
Organic matter	0.98 %
Nitrogen	0.82 mg kg^{-1}
P_2O_5	0.02 mg kg^{-1}
K_2O	43.4 mg kg^{-1}
pH	8.5

Prior to seed sowing, the field was thoroughly ploughed, harrowed and leveled to have efficient distribution of irrigation water. Farm Yard Manure (FYM) was added to the soil. Four main plots were divided into 7 sub plots with 91.44cm length and 76.20cm width. In each treatment, 100 seeds were sown keeping 7.62cm row to row and 10.16 cm plant to plant distance. The field was irrigated after sowing. Seed of spinach cv. Kandiari was used in this project. When sown, days to emergence, germination percentage (%), survival percentage (%), plant height (cm) were measured and after harvesting leaf area (cm^2), leaf yield (tons ha^{-1}) and 100 seed weight (gm) were deliberated accordingly which were significantly altered by priming of different sources and various soaking durations.

Results and Discussion

Days to emergence: The mean values in Table 1 indicated significant effect among various sources. Maximum 7.00 days to emergence were recorded in seed treated with distilled water, followed by 6.67 days taken by seeds soaked in DAP solution and minimum days (5.95) were taken by seeds drenched in SSP+Na_2CO_3 solution. Results of various soaking durations also proved effective indicating that priming significantly reduced the number of days to emergence. Un-primed seed took 7.50 days as compared to 5.92 days in seeds soaked for 24h. Likewise, in their interaction, un-primed seed took maximum days (7.67) to emergence followed by (7.33) days observed in seed soaked in distilled water for 4h. On the other hand, seeds flooded for 24h in SSP + Na_2CO_3 solution took minimum days (5.00) to emergence.

Seed emergence is a key component for the success of crops. Proper amount of water, oxygen, temperature and types of soil are among the prerequisite for adequate emergence. Besides, these external factors, the viability of the seeds also play crucial role in the emergence. Best results in phosphorus solutions endorsed the role of phosphorus in promoting of seed emergence. However, it can also be assumed that among phosphorus solutions, neutral pH may be better than acidic one (SSP vs SSP+Na_2CO_3 solution) for priming of spinach seeds. These results are in agreement with work of Arif *et al.*, (2005) who reported that early emergence of the primed seeds might be due to the completion of pre-germinative metabolic activities during priming process, making the seed ready for radical emergence and the seeds germinated soon after planting compared with untreated dry seeds. The current results are also in line with the work of khan *et al.*, (2005) who reported faster emergence and increased germination of primed seed as compared to un-primed (control).

Germination percentage: The effect of priming on spinach seed germination is clear from Table 1, showing that germination percentage (88.14%) was the highest in seeds soaked in SSP+Na_2CO_3 solution, closely followed by (85.19%) in seeds soaked in SSP solution. While the lowest (81.81%) was noticed in distilled water soaked seed. The results of various soaking durations indicate that maximum germination percentage (89.42%) was recorded in seeds drenched for 24h, followed by 87.33% in seeds remained in solution for 20h compared to 77.83% in un-soaked seeds. However, in their interaction maximum germination (95.33%) in seeds soaked for 24h in SSP+Na_2CO_3 solution, followed by 92.33% germination percentage in seeds soaked for 20h in SSP+Na_2CO_3 solution. Minimum percentage (77.0%) was observed in un-primed seed plot.

The increase in germination rate may be credited to priming which induces quantitative changes in biochemical contents of the seeds, membrane integrity and enhances physiological activities during seed germination. Phosphorus absorption may have triggered the process. These findings are in agreement with the work of Ullah *et al.*, (2002) who reported beneficial effects on emergence rate of seed treated with micronutrient. Likewise, Rashid *et al.*, (2006) also reported that “On-farm” seed priming proved effective in producing earlier emergence, high germination percentage and increased yields in a range of crops in many diverse environments. Similarly, Kurdikeri *et al.*, (1995) recorded analogous results due to maize seed priming in 2.5% solution of KH_2PO_4.

Survival percentage: The mean values in Table 1 indicated that among various sources for seed priming, SSP+Na_2CO_3 solution gave the best results in increasing survival percentage (89.96%), followed by SSP solution (87.14%), while distilled water exhibited least values (83.89%). Likewise, results of various soaking durations revealed that seed soaking increased the survival percentage with the highest value (90.40%) in 24h soaking followed by (89.47%) 20h as against plot having the unprimed seeds with the least survival percentage (81.89%). Similarly, in their interaction maximum survival percentage (95.38%) was recorded in plot in which seeds were soaked for 24h in SSP+Na_2CO_3 solution, chased by (94.23%) survival percentage in plot in which seeds were soaked for 20h in SSP+Na_2CO_3 solution. Minimum survival percentage (81.60%) was observed in plot in which seeds were un-primed.

Seeds may get infected by many different pathogens and some pathogens are present inside the seed (embryo, cotyledons), while others are present in their seed coat as contaminants. When the seed is sown, these pathogens infect the young seedlings and hence decrease seed germination percentage and plant cannot survive. Phosphorus inactivates these pathogens and avoids early seedling infection, hence, may result in more survival percentage of primed seed. These findings are in agreement with the work of Musa *et al.,* (1999) who stated that seed priming in chickpea significantly reduced the damage caused by collar rot (*Sclerotium rolfsii*) in Bangladesh in two different seasons.

Plant height (cm): It is evident from Table 2 that the tallest plants (31.24 cm) were noticed in plots in which the seeds were soaked in SSP+Na_2CO_3 solution, followed by (29.67 cm**)** in which the seeds were soaked in SSP solution. On the other hand, shortest stature plants (27.00 cm) were found in distilled water plots. Similarly, results of various soaking durations revealed that maximum plant height (31.16 cm) was recorded in plot in which the seeds were soaked for 24h, followed by (30.24 cm) plant height in plot in which the seeds were soaked for 20h. Minimum plant height (25.03 cm) was observed in control plot. Similarly, the interaction results show that seeds soaked in SSP+Na_2CO_3 solution for 24h gave the tallest plants (33.70 cm), trailed by (32.54 cm) seeds soaked for 20h in SSP+Na_2CO_3 solution, and the shortest plants (24.38 cm) were observed in un-primed seed plot.

Both environmental and genetic modalities may be accounted for the variability in plant height. Additionally, vegetative and reproductive growth potential of plants is also responsible for superior plant height. Furthermore, the probable reason could be that priming of spinach seeds resulted in an increased seedling vigor and strength and more established root growth, which enhanced the plant competency for light, water and nutrients resulting in more established plants. These results confirmed the findings reported by Rashid *et al.,* (2002), who illustrated that seed priming improves the plant growth and stand. Moreover, Asgedom & Becker (2001) monitored that P and Zn primed seeds showed higher vigor than unprimed seed as reflected in maximum plant height. Additionally, Ihsan *et al.,* (2011) observed that more plumule length was observed when grass seeds were primed with $CaSo_4$ and 50 mM $CaCl_2$.

Leaf area (cm^2): The mean values in Table 2 showed significant effect of priming on leaf area. Among different sources of seed priming, SSP+Na_2CO_3 solution resulted in maximum leaf area (63.12 cm^2), tracked by SSP solution with 57.94 cm^2 leaf area, while distilled water seed priming ended up with minimum leaf area (44.94 cm^2). Likewise, among various soaking durations, 24h soaking gave the best results with 60.72cm^2 leaf area, followed by 20h soaking with 59.47 cm^2 leaf area, as compared to unprimed seed plots having the least leaf area (41.23 cm^2). Similarly, in their interaction, 24h seed soaking in SSP+Na_2CO_3 solution resulted in maximum leaf area (70.78 cm^2), followed by 20h in SSP+Na_2CO_3 solution with 70.17 cm^2 leaf area, while unprimed seed plots exhibited the poorest results having 40.16cm^2 leaf area (Table 3).

The observed increase in leaf area of spinach plants for priming might be due to established root system and improved emergence and seedling growth of primed seeds. Couple of research studies (Basra *et al*., 2003, Harris *et al.*, 2001, Harris *et al*., 1999, Ghosh *et al.*, 1997) depicted that priming of seeds with different chemicals increased number of tillers and leaf area index, dry matter accumulation, growth rate and yield compared with control.

Leaf yield (tons ha^{-1}): Leaf yield as displayed in Table 2 was significantly affected by priming. It was indicated that seed soaking in SSP+Na_2CO_3 solution gave the highest yield per hectare (14.67 tons), closely pursued by SSP solution with (13.50 tons ha^{-1}) yield, while distilled water seed priming gave the minimum yield per hectare (10.885 tons). Likewise, with respect to various soaking durations, 24h seed soaking gave the maximum yield (14.340 tons ha^{-1}), chased by 20h soaking with 13.874 tons ha^{-1} yield. Contrary to the primed seed, unprimed seeds plot had the minimum yield (9.719 tons ha^{-1}). Similarly, in their interaction 24h seed soaking in SSP+ Na_2CO_3 solution resulted in the highest yield per hectare (16.257 tons), succeeded by 20h seed soaking in SSP+Na_2CO_3 solution (15.937 tons ha^{-1}) yield as compared to unprimed seeds plots with the lowest yield per hectare (9.436 tons).

Table 3. Effect of various sources of priming and soaking durations on 100 seed weight (g) of Spinach.

Soaking durations	Sources for 100 seed weight (g)				
	Distilled water	**DAP**	**SSP**	**SSP + Na_2CO_3**	**Mean**
0 h	0.671 j	0.705 j	0.704 j	0.683 j	0.691 E
4 h	0.711 j	0.834 fg	0.795 ghi	1.005 bcd	0.836 D
8 h	0.727 ij	0.836 fg	0.799 ghi	1.012 bc	0.844 CD
12 h	0.744 hij	0.845 fg	0.857 fg	1.047 b	0.873 C
16 h	0.805 gh	0.888 ef	0.937 de	1.066 ab	0.924 B
20 h	0.834 fg	0.893 ef	0.949 cde	1.067 ab	0.936 AB
24 h	0.842 fg	0.905 ef	0.996 bcd	1.121 a	0.966 AB
Mean	**0.762 C**	**0.844 B**	**0.863B**	**1.000 A**	

LSD value for different sources = 0.0413

LSD value for various soaking durations = 0.0367

LSD value for interaction = 0.0734

Values followed by different letters are significantly different at $p \leq 0.05$ level (lower case) and $p \leq 0.01$ level (upper case) according to LSD test

Yield is the utmost and final output of any crop depending upon various factors such as genetic makeup, soil types and environmental factors. The increased biological yield due to priming in spinach might be due to early seedling growth, improve plant stands, reduced diseased and better plant nutrition as reported by Rashid *et al.*, (2002). The improved yield of primed seeds plots may be due to uniform and vigorous seedling growth, well-developed root system and efficient subsequent growth that eventually led to higher grain yield reported by Harris *et al.*, (2001). These results endorse the findings of Basra *et al.*, (2003) who reported that priming treatment significantly increased total biomass and plant weight as compared with unprimed (control).

100 Seed weight (g): Significant effect of priming on 100 number seed weight was noticed while comparing different seed priming sources. Seed soaked in SSP+ Na_2CO_3 solution resulted in maximum 100 number seed weight (1.0 g), followed by seed priming in SSP solution with 0.863g compared to distilled water seed priming that led to the minimum 100 seed weight (0.762 g). Findings of various soaking durations indicated that 24h soaking gave the best results with maximum 100 seed weight (0.966gm), followed by 20h soaking having 0.936gm per 100 seed weight, while unprimed seeds plot exhibited the lowest values per 100 seed weight (0.691 g). Similarly, in their interaction, maximum 100 seed weight (1.121 g) was recorded in plot in which seeds were soaked for 24h in SSP+ Na_2CO_3 solution, followed by (1.067 g) weight in seed soaked for 20h in SSP+ Na_2CO_3 solution and minimum 100 seed weight (0.671 g) was observed in plot in which seeds were un-primed.

These current results are supported by the findings of Mauromicale *et al.*, (2000), who reported that seed priming as a mean to improve early flowering, maturity time and yield of a crop due to early seedling growth and enhanced plant nutrition because of priming. These results also approved the findings of Basra *et al.*, (2003), who observed that priming treatment significantly increased total biomass, weight and seed yield as compared with unprimed. Moreover Yousaf Et al., (2011) reported that seed priming significantly increased fresh as well as shoot dry weight indifferent wheat varieties.

Conclusions Recommendations

Based on current findings, it can be concluded that seed primed with SSP+Na_2CO_3 solution produced best results, followed by SSP and produced more yield as compared to un-primed seed. Likewise, seed soaking durations from 16h to 24h proved to be the best range.

Based on current experimental results among phosphorus sources and durations, soaking in SSP+Na_2CO_3 for 24 hours is recommended for seed priming in spinach. Priming in SSP+Na_2CO_3 may be used as a tool for boosting early germination, rapid seedling height and higher leaf yield.

The study proved the positive effect of priming (sources and durations) on spinach. However, there is a dire need for further investigations to explore the effect of seed soaking durations for extended period, to envisage the secretes of priming effects at molecular and biological levels, to educate the farmers about priming of spinach seed in SSP+Na_2CO_3 as an easy and low cost practice to enhance spinach production.

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