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Effect of Seed Soaking Durations and NPK Levels on Germination and Growth Dynamic of Chickpea (*Cicer arietinum* L.) Under Dryland Conditions

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Abstract

Chickpea (*Cicer arietinum* L.) is a vital legume crop regarding its high protein content and adaptability to semi-arid conditions, which make it a stable in diverse agricultural systems. Current experiment was designed to evaluate the effects of water soaking durations and NPK levels on the growth of chickpea under semi-arid conditions of Thal-Khushab, Punjab. The experiment was conducted in Randomized Complete Block Design (RCBD) with 4 replications and 20 treatments consisting of all possible combinations of 5 water soaking durations (W0=no water soaking, W1=soaking for 30 mints, W2= soaking for 60 mints, W3= soaking for 90 mints, W4=soaking for 120 mints) and 4 fertilizer levels (NPK) (F0=no NPK, F1=20:40:20 kg ha^{-1}, F2= 25:50:25 kg ha^{-1}, F3=30:60:30 kg ha^{-1}). Data of growth parameters was recorded and analyzed using ANOVA, LSD test which showed a significant effect of the treatments. Among the growth parameters, the minimum emergence time was recorded under W2F2 (5.96 days), maximum plant stand count (100m^{-2}) was recorded with W2F1, maximum Primary branch number (8.37 per plant) under W2F2, maximum plant height (120.59 cm) with W1F3, maximum Biomass Yield (kg ha-1) with W0F3 and maximum harvest index (6.3) was recorded with treatment W4F2. Correlation test was also conducted, which showed mixed response including positive, negative and no association among the different parameters.

Keywords: Correlation, Drought, Harvest index, Plant Growth, Pod Yield

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Introduction

Pulses are important group of Leguminosae family which have ability to fix atmospheric nitrogen (Kumar et al., 2023), thrive on relatively less soil nutrients and possess capacity to withstand water scarcity hence suitable for different cropping systems over a wide range of soils (Balo & Mahata, 2022). In Pakistan, pulses are being grown on 1.492 million hectares with 983,000 tons production (Ahmad et al., 2022). Chickpea covers a major chunk in total production and covered area (Ullah et al., 2020) whereby growing on 1185 thousand hectares with 6699 metric tons production (Anonymous, 2022-23). Pakistan lies in the leading countries of chickpea production in the world i.e. India, Italy, Greece, and Egypt (FAO, 2020).

Around the globe, chickpea (*Cicer arietinum* L.) is being grown in various climates including subtropical, semi-arid and arid regions mostly on the soils where moisture conserved following the rainy season (Berger et al., 2004). Chickpea is considered a drought-tolerant crop because of its extensive cultivation in the arid and semi-arid tropics (Naveed et al. 2024). In these environments, drought is a typical limiting factor that is often quantified by growth andleaf-level metrics (Pang et al., 2017). Predominantly soil moisture and up to some extent temperature are the major limiting factors against successful chickpea crop production (Krishnamurthy et al., 2013). Management strategies that ensure emergence and establishment of crop plants lead to a vibrant crop stand (Anwar et al., 2003). Chickpea cultivation involves various sowing practices, including surface sowing and deep planting. The crop is typically grown as a dryland or rainfed crop, relying on stored soil moisture. Deep band placement has emerged as a promising technique, particularly in arid regions, as it ensures better seed-to-soil contact and allows plants to access deeper soil moisture (Mubvuma, 2018). Sowing depth significantly impacts germination and crop establishment, with hypogeal emergence making sufficient seed depth and friable soil conditions essential (Raina et al., 2019). It has been observed that pre-sowing seed treatments improve legume germination; similarly, chickpea germination can be improved and their efficiency (Kumar et al., 2022). Soaking seeds is a straight forward pre-sowing procedure that causes many plant species to germinate and thrive uniformly (Shrestha et al., 2021). To put it simply, seed soaking is a carefully regulated hydration process that raises the rate, homogeneity, and occasionally the percentage of total germination of seeds (Esatu, 2023).

In Pakistan, chickpea is being grown in dry land areas whereby facing soil moisture deficit at the time of sowing either due to early cessation of monsoon rains or poor soil moisture conservation practices. Maximum seed emergence necessitates soil moisture levels near field capacity (Babaeian et al., 2019). It has been reported that soil water contents nearly 33–75% of field capacity decreased seed germination and emergence of chickpea (Chadha et al., 2019), which is owing to poor seed absorption and uneven emergence caused by low soil moisture content (Jarrar et al., 2023). Vibrant crop stand establishment and grain yield are positively correlated with healthy seedling emergence and establishment (Reed et al., 2022).

Chickpea crop in semiarid regions faces abiotic including imbalanced nutrient application (Silberbush, 2002). Soil nutrients play a key role in enhancing crop yield and quality (Ali et al, 1997). Nitrogen, Phosphorus and Potassium (NPK) are major soil nutrients which are needed by plant in relatively large quantity. However, in arid and semi-arid regions, chickpea is usually grown without application of these major nutrients which lead to low yield. Literature shows that chickpea positively responds to the application of NPK at the time of sowing. But quantity of NPK applied entirely depends upon cultivar and available soil moisture and average precipitation of the area (Ruhul et al. 1998). Determination of optimum levels of NPK fertilizers is essential for obtaining maximum economic returns. According to Ananthi et al. 2010, best rate of fertilizer application is that which gives maximum economic returns at least cost. Among various essential plant nutrients, the macro nutrients NPK are crucial for determining the yield and quality. The objectives of this study was to determine the effect of different seed soaking periods and levels of NPK on germination and growth of chickpea crop under agro economic conditions of Khushab.

Materials and Methods

Experimental Specifications

The experiment was conducted during chickpea growing season 2022-23, at village billu farm, Thal area of Khushab, Punjab, Pakistan. Experimental site lies at 32.16^o N, 72.20^o E. Experiment was carried out in randomized complete block design (RCBD) with 20 treatments and 4 replications. There were 80 plots in this experiment, and each plot had area of 6.12 m^2. Among the treatments, there were 5 water soaking durations (W0 = No soaking, W1= 30 mints soaking, W2 = 60 mints soaking, W3 = 90 mints soaking, W4 = 120 mints soaking) and 4 levels of NPK (F0= No Fertilizer, F1= NPK 20:40:20 kg ha^{-1}, F2 = NPK 25:50:25 kg ha^{-1}, F3 = NPK 30:60:30 kg ha^{-1}) whereby making 20 treatments in all possible combinations. The Bittal-2021 was used to conduct this experiment.

Crop Husbandry

The sandy loam soil of the experiment site was ploughed with the help of ordinary cultivator followed by planking. The experimental site had soil with low moisture content between 21% - 40%. Seed after soaking along with fertilizer levels of fertilizer were sown with hand drill having modified tine of deep band placement whereby fertilizer was place approximately at the depth of 5 inches, and seed @ 60kg ha^{-1} was sown above 2 inches of the fertilizer in this way both fertilizer and seed were in band placement. Row to row distance was maintained 30cm and plant to plant distance 10cm. After 20 days of sowing, thinning was done to maintain proper plant-to-plant distance. To prevent yield losses from weeds, manual weeding was done, first weeding was done at the time of thinning and second one after 30 days of 1st weeding.

Data Recording

Days to emergence were measured by taking readings of first true leaf to the last plant. Plant stand count were measured by counting the total number of emerged plants in each plot after completion of germination. The number of primary branches, at maturity, were counted by examining the main stem of randomly selected 10 plants and the average was calculated. At maturity, plant height from base to top of plant was measured with meter rod. Biomass yield (kg ha^{-1}) was recorded by harvesting chickpea from the area of 1m^2 from each plot, weighed and converted into biomass yield. For calculation of harvest index, area of 1m^2 from each treatment was harvested pods were removed, threshed and yield was calculated. After that the harvest index was calculated by using its formula.

Statistical analysis

The recorded data was analyzed statistically by using R software.

Results and Discussion

Days to Emergence

Data shows that all the treatment factors namely seed soaking durations and nutrient levels were significantly ($p< 0.01$) influenced days to emergence in chickpea. The LSD test results in Fig. 1 showed that the treatment W2F2 resulted in the fastest emergence (5.96 days) followed by W3F2 W0F3 both showing 6.3 days. Whereas the longest seedling emergence time (16.71 days) was recorded under W4F3. A strong correlation was found between days to emergence and biomass yield (Table 1) however it was a negative correlation. The soaking duration boosts early seed metabolic activity in and early nutrient uptake which result in early germination (Basra et al., 2005). In contrast, the slowest emergence was likely to delayed start of seed metabolic activities and ionic toxicity from high nutrient level (Ashraf et al., 2008). Our findings are in line with Basu et al. (2020), where seed soaking improves the early metabolic events, consequently accelerating germination, and Patel et al. (2017), where pre-sowing treatments in combination with nutrients increases seedling emergence and vigor.

Plant Stand Count

Analysis of the data presented in Fig.2 showed that combination of both seed soaking durations and NPK levels significantly impacted chickpea plant stand count. Maximum plant stand count (100m^{-2}) was recorded under the treatment W2F1 followed by both W2F2 and W2F3 showing showing 75.71m^{-2} and 75.1 m^{-2} respectively. While minimum plant stand count was recorded under the treatment W0F0 whereby showing 25.2 plants m^{-2}. A significant correlation was recorded between plant stand count and harvest index as presented in Table 1. Our findings are consistent with previous studies by Harris et al. (2001), who founded that seed soaking improves germination and plant growth, and Yadav et al. (2018), who demonstrated that proper NPK fertilizer enhances chickpea growth. The findings emphasize the role of seed soaking and balanced fertilization in improving chickpea yields.

Number of Primary Branches

Analysis of the data for primary branch number in chickpea (Fig.4) showed significant effect ($p < 0.01$) of seed soaking durations in combination with NPK levels. Among the treatments, W2F2 produced the highest number of primary branches (8.37 per plant) followed by W2F3 (7.2). While minimum number of primary branches were recorded under the treatment W3F1 (1.55). The increased number of primary branches probably due to better germination and availability of nutrient for better growth and development. The correlation matrix Table 1 indicates that there was association between primary branch number and any other parameter in the table. These results are consistent with Baloch et al. (2012), who found that seed soaking enhances branching, and Alam et al. (2010), who reported that fertilization boosts branching through improved nutrient uptake.

Plant height (cm)

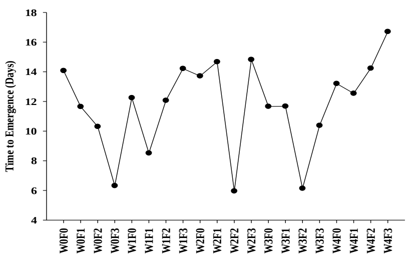
Statistical analysis of the experimental data shows that seed soaking durations and NPK levels significantly influenced ($p < 0.01$) the plant height of chickpea at maturity as shown in Fig.5. The highest plant length (90 cm) was recorded under the treatment W1F3 followed by W0F3 showing plant height 85 cm. whereas minimum plant height (23.89 cm) was recorded under the treatment W3F1. The plant height was significantly responsive to the higher NPK levels, it was so owing use of these nutrients in tissue development. The parameters of our study did not show any association with plant height as indicated in table 1 of correlation matrix. These findings are consistent with El-Hendawy et al. (2008), who found that fertilizer application improves plant height in legumes by enhancing nutrient uptake. Afzal et al. (2006) also reported that seed soaking improved plant vigor and biomass under nutrient-rich conditions.

Biomass Yield (kg ha^{-1})

Results of ANOVA about the significance of the treatments and subsequent LSD test indicates that among seed soaking durations its combination with NPK levels, the treatment W0F3 produced maximum biomass yield i.e. 12,196 kg ha^{-1} followed by W3F3 which produced 10,811 kg ha^{-1} biomass. Among the treatments, least effect on biomass yield was observed under the treatment W4F2 whereby produced 4001 kg ha^{-1}. Table 1 of the correlation matrix showed that there was correlation between biomass yield, days to emergence and harvest index, however, this correlation was negative. The findings of this study show that if the correct soaking time is used in combination with proper NPK level, desirable biomass yield in chickpea can be achieved. The results observed in this study are in consonance with Hullain, et al., (2019) and Nadeem, et al., (2021) whereby seed soaking and optimum rate of fertilizer application enhanced biomass production.

Harvest index (HI)

The ANOVA results for the harvest index (HI) of chickpea (Fig.7) showed highly significant effects of seed soaking duration in combination with NPK levels ($p < 0.01$). Among the treatments, maximum harvest index (6.3) was calculated with the treatment W4F2. While minimum harvest index was calculated under the treatment W0F3 however it was not significantly different from that of W3F3 and W4F0. Our correlation test as presented in Table 1 indicates that there was a positive correlation between harvest index and plant height. Findings of our experiment are in line with the results of Abbas 2019, where he suggested that fertilization enhanced harvest index through improving grain production and Hussain and Qureshi 2020, asserted that seed soaking augmented HI with increased plant vigor and allocation of resources.



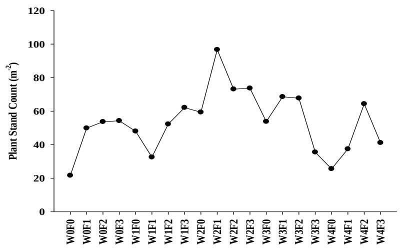
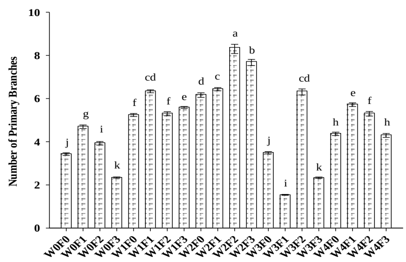


Fig. 1: Effect of Seed Soaking Durations and NPK Levels on Time to Emergence of Chickpea.
Fig 2: Effect of Seed Soaking Durations and NPK Levels on Plant Stand Count of of Chickpea



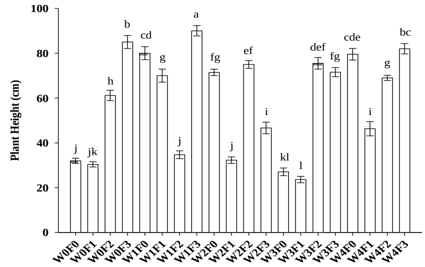


Fig. 3: Effect of Seed Soaking Durations and NPK Levels on Number of Primary Branches of Chickpe
Fig. 4: Effect of Seed Soaking Durations and NPK Levels on Plant Height of Chickpea

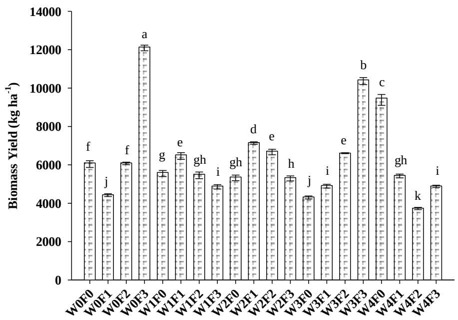


Fig. 5: Effect of Seed Soaking Durations and NP Levels on Biomass Yield of Chickpea

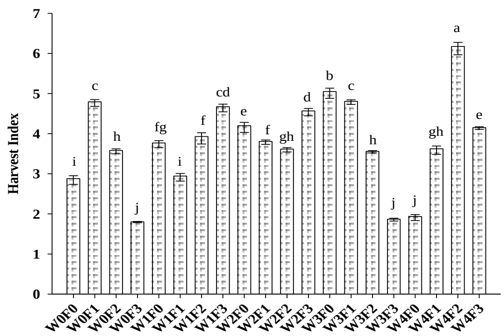


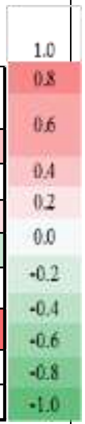
Fig. 6: Effect of Seed Soaking Durations and NPK Levels on Harvest Index of of Chickpea

Table 1. Correlation Matrix of Growth Parameters of Chickpea

	Days to Emergence	Plant Stand	Primary Branch	Plant Height	Biomass Yield	Harvest Index
Days to Emergence	1	-.048	-.013	-.143	-.469*	.412
Plant Stand Count	-.048	1	.400	-.270	-.204	.482*
Primary Branch	-.013	.400	1	.086	-.305	.239
Plant Height	-.143	-.270	.086	1	.286	-.293
Biomass Yield	-.469*	-.204	-.305	.286	1	-.890**
Harvest Index	.412	.482*	.239	-.293	-.890**	1

*. Correlation is significant at the 0.05 level

**. Correlation is significant at the 0.01 level



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