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Impact of Phosphorus Levels on Vegetative Growth and Seed Yield of Lettuce (*Lactuca sativa* L.) Cultivars

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Abstract

The study was conducted to investigate the effects of different phosphorous levels on the growth and seed yield of the lettuce (*Lactuca sativa* L.). Two lettuce varieties namely Grand Rapids and Romaine were tested on various phosphorus fertilizer levels i.e. 60 kg and 80 kg per hectare using Randomized Complete Block under factorial Design (RCBD). The treatment without phosphorus was seed parameters as well as sensory evaluation including crispiness and color were examined after interval of each 10 days. We report that the increase in the phosphorus fertilizer has positive effects on yield, ground cover and shelf life of both varieties; however Grand Rapids significantly showed superior performance than that of Romaine. Furthermore, Romaine developed seeds not observed in case of Grand Rapids cultivar seemingly due to insufficient chilling hours required for phase transition. Further investigations are suggested at molecular level to decipher the components involved in better yield and seed development in both varieties tested.
Key Words: Lettuce, Seed yield, Shelf life, Seed production, Phosphorus levels.

Özet

Marul (*Lactuca Sativa* L.) Çeşitlerinin Tohum Verimi ve Vejetatif Gelişimi Üzerine Fosfor Düzeylerinin Etkisi

Bu çalışma marul (*Lactuca sativa* L.)'da büyüme ve tohum veriminde farklı fosfor düzeylerinin etkisini araştırmak amacıyla yapılmıştır. İki farklı marul çeşidi, Grand Rapids ve Romaine sırasıyla 60 kg/ha ve 80 kg/ha olmak üzere iki farklı fosforlu gübre düzeyinde tesadüf blokları (RCBD) deneme deseni kullanarak test edilmiştir. Denemelerin fosfor olmaksızın tohum parametreleri ile duyusal olarak değerlendirmesinin yanı sıra, tohumun gevrekliği ve rengi her 10 günde bir incelenmiştir. Fosforlu gübrenin artışının her iki marul çeşidinin verimi, yer örtüsü ve raf ömrü üzerinde olumlu bir etkiye sahip olduğu görülmüştür. Bununla birlikte, Romaine çeşidine kıyasla Grand Rapids çeşidinin tohum gelişiminde faz geçişi olması için yeterli ölçüde soğuğa maruz kalmamasına rağmen, Grand Rapids'in verim bakımından Romaine'den önemli ölçüde daha üstün bir performans gösterdiği bildirilmiştir. Test edilen iki marul çeşidinin daha iyi bir verim ve tohum gelişimi göstermelerini etkileyecek olan bileşenlerin işlevlerinin çözümlenmesi için, moleküler düzeyde daha fazla araştırma yapılması önerilmektedir.
Anahtar Kelimeleri: Marul, Tohum verimi, Raf ömrü, Tohum üretimi, Fosfor düzeyleri.

Introduction

Lettuce (*Lactuca sativa* L.), the king of salad vegetable belongs to family compositae, rules in the meals of people throughout the world. Since ancient times, it has been cultivated. Pictures of a pointed leaved lettuce have been found in Egyptian tombs. It is believed that first time Lettuce seeds were introduced to the new world by Columbus (Anonymous, 2004).

Lee (1999) reported that, lettuce plant is fairly hardy and cold weather vegetable that thrives when the average daily temperature is between 60 and 70ºF. It is cultivated in early spring or late summer. In high temperatures its growth is stunned. However, there are also some types and varieties of lettuce which can withstand heat better than others. According to some researchers lettuce is categorized into four groups of growth habits namely head type, semi heading type, loose leaf type and cos or romaine type. In this mechanized and advanced period people are very much conscious about their diet but have deprived themselves of balanced diet. Leafy crops are advised to avoid health problems by the medical professionals. Lettuce is very important and affordable leafy vegetable for public consumption. Weiss (1998) reported that, lettuce contains anticancer agents. Lettuce is an exotic but still less popular crop of Pakistan and is facing problems like less leave and seed yields. One of the major problems is acclimatization of varietals characteristics. It had been long ago

observed by Steel and Briggs (1929) that lettuce needs cool climate for leaf production and requires long days with relatively warmer climates for seed production. Thus the main objective of this project was to evaluate maximum leaf and seed yield indicators by suitable doses of phosphorus manipulation under various climatic regimes.

Materials and Methods

The experiment was carried out in the vegetable area of Institute of Horticulture, University of Agriculture Faisalabad, Pakistan and some parts of the experiment were carried out in Northwest A&F University, Shaanxi, Yangling, China. The plant material used consisted of two lettuce varieties i.e. Grand Rapids and Romaine. Seeds of these varieties were procured from Ayub Agriculture Research Institute (AARI), Faisalabad. Single super phosphate (SSP) fertilizer was applied 60 and 80 kg P_2O_5 ha^{-1}, however 0 fertilizers were treated as control. The experiment consisted of following six different treatments and each treatment had 4 replications.

T1= V_1F_0	0 kg P_20_5 ha^{-1},	80 kg N ha^{-1},	60 kg K_2O ha^{-1}
T2= V_1F_1	60 Kg P_20_5 ha^{-1},	80 Kg N ha^{-1},	60 Kg K_2O ha^{-1}
T3= V_1F_2	80 Kg P_20_5 ha^{-1},	80 Kg N ha^{-1},	60 Kg K_2O ha^{-1}
T4= V_2F_0	0 Kg P_20_5 ha^{-1},	80 Kg N ha^{-1},	60 Kg K_2O ha^{-1}
T5= V_2F_1	60 Kg P_20_5 ha^{-1},	80 Kg N ha^{-1},	60 Kg K_2O ha^{-1}
T6= V_2F_2	80Kg P_20_5 ha^{-1},	80 Kg N ha^{-1},	60 Kg K_2O ha^{-1}

Data was recorded regarding different parameters of growth and yield i.e. number of leaves at marketable stage, plant height at marketable stage, ground cover area (Qs=Ma x Mb), leaf area, normal leaves, abnormal leaves, leaves fresh weight, oven dried weight, storage behavior at 4ºC, shelf life and seed parameters were recorded on the interval of each 10 days. Meteorological data of the experimental period also examined.

Data Analysis

The experiment was arranged according to RCBD with factorial arrangement. The collected data was analyzed statistically by using the variance technique. Duncan's new multiple arrange test at 0.5% probability was applied to compare the difference among the treatment means (Peterson, 1994).

Results

The study involved determining the effect of different phosphorus levels on growth and seed yield of lettuce cultivars *viz.*, Grand Rapids and Romaine.

Plant Physiological data

Plant growth like number of leaves, plant height and ground covered area were examined on the basis of different plant parts. The number of leaves $plant^{-1}$ were recorded at marketable stage (08 weeks old) and highly significant results for fertilizer treatments and non-significant result for variety fertilizer interaction were noticed (Figure 1.). Plant height and ground cover of both cultivars exhibited significantly similar trend of development at increasing doses of fertilizer and vice versa (Figure 2. and Figure 3.).

Storage behavior of lettuce

The leaf samples were stored at low temperature i.e. 4ºC and room temperature i.e. 25–38ºC to observe the storage behavior and the results were recorded. Statistical analysis showed that, among varieties and varieties–fertilizer interaction had non–significant results. However, fertilizer application reflected significant results. The leaves of the treatment having 60 kg phosphorus per ha remained fresh up to 9.6 days after harvesting (Figure 4). Although all the treatments exhibited non–significant interaction once placed at room temperature condition, but those provided higher doses of fertilizer withstand longer period of time to some extent (Figure 5.).

Sensory evaluation for taste, crispiness and color

The results were evaluated through Hedonic scale method and the analysis of variance showed that varieties did not exhibit any significant response for the evaluation of best taste, crispiness and color. However, Grand Rapids found better in taste, crispiness and color than Romaine (Figure 6.). As far as the doses of phosphorus fertilizer are concerned the plant leaves receiving applied fertilizer 80 kg P_2O_5 stand first as compare to others and treatment with no phosphorus ranked very poor in taste, crispiness and color.

Seed parameters

At the stage of maturity the seed parameters were also examined it is worth mentioning here that the maturity stage of both cultivars reached during the month of February to March. Insufficient photoperiod at particular growing stage undermined the bolting phenomenon of Grand Rapids resulting in no seed production, whereas Romaine did not exhibit non bolting phenomenon and produced seeds and remained the only choice for evaluating seed parameters. Relatively high temperature and an ample amount of photoperiod for inducing bolting phenomenon in lettuce were also discussed by Steel and Briggs (1929). Data of seed weight plant^{-1} were analyzed statistically and the result revealed highly significant fertilizer treatments. Therefore, the 80 kg dose of phosphorus produced 7.6 gm seed per plant and remained superior to other treatments (Figure 7.).

Seed weight per plot of various treatments were recorded and it found that the plot having high dose phosphorus (80 kg) and also having the direction from north to south produced higher seed yield of Romaine variety may be due to the appropriate light intensity and photoperiod (Figure 8.).

Discussion

The study involved determining the effect of different phosphorus levels on growth and seed yield of lettuce cultivars Grand Rapids and Romaine.

Plant Physiological data

The arrangement of means reveals no significant superiority of Grand Rapids over Romaine. However, treatment of 80 kg Phosphorus produced 14.87 leaves per plant^{-1} and remained superior (Figure 1.). The results were identical with the findings of Hadid et al. (1990) and Moreia et al. (2001), who reported that phosphorus application increases lettuce leaf yield. Similar findings were reported by Hilda and Fraga (1999) who demonstrated that the use of phosphate solubilizing bacteria as inoculants not only increases phosphorus uptake but also improve crop yield significantly. Deficiency and unavailability of phosphorus as a growth limiting nutrient regarding plant vigor and yield is well documented and proven extensively, our findings are also in concomitant with Gyaneshwar et al. (2002), who elaborated the role of phosphorus as a growth limiting factor in many herbaceous plants. Availability of phosphorus is much more vital for the better growth and biochemical functions of plant as reported by Azone et al. (2003), although application of phosphorus with other nutrients and microbes in many combinations during different times were investigated but still it is quite ambiguous to calculate optimum application and combination of phosphorus at different ecological zones.

Plant height at maturity were analyzed statistically and showed significant results for varieties and non-significant results for varieties fertilizer interaction (Figure 2.). Similar results were also reported by Misra and Dinesh (1995), Santos et al. (1998) and Vergote (1998). They reported that, high phosphorus fertility enhances the competitive ability and plant height of lettuce.

The ground cover area (cm^2) reflected highly significant results for varieties, fertilizers and varieties-fertilizer interaction. The mean value of the fertilizer treatments showed that high fertilizer doses had significantly induced superior crop performance over other treatments (Figure 3.).
The results were parallel to the findings of Misra and Dinesh (1995) and Santos et al. (1998) who found the positive correlation among the ground cover area and phosphorus fertilization.

Storage behavior of lettuce

The results are in close association with the findings of Sanchez et al. (1989) and Santos et al. (1998). Shelf life behavior of lettuce leaves at room conditions (20–25ºC and 60–65% RH) was also studied and the results showed that varieties-fertilizer treatment and varieties–fertilizer interaction

remained highly significant at 4ºC (Figure 4.). The (Figure 5.) indicates that 80 kg phosphorus per hectare dose had highly significant upper hand over other treatments of phosphorus.

Sensory evaluation for taste, crispiness and color

The results were endorsed with the findings of Vergote (1998) and Yongryul et al. (1999), by stating that judicious rate of phosphorus fertilizer increases the quality parameters of lettuce leaves (Figure 6.).

Seed parameters

The results are in confirmatory with the results of Imas et al. (1998) and Rice (1999). According to them the seed yield would be significantly improved at higher phosphorus regimes.

Seed weight per plot of various treatments were recorded and it found that the plot having high dose of phosphorus (80 kg) and also having the direction from north to south produced higher seed yield of Romaine variety may be due to the appropriate light intensity and photoperiod (Figure 7.).

Recommendations

On the basis of results observed from the experiment it is suggested that for the sub-temperate zone of Pakistan the marketable better leaf quality of lettuce can be taken from Grand Rapids cultivar whereas, for seed production Romaine may be the best choice for cultivation.

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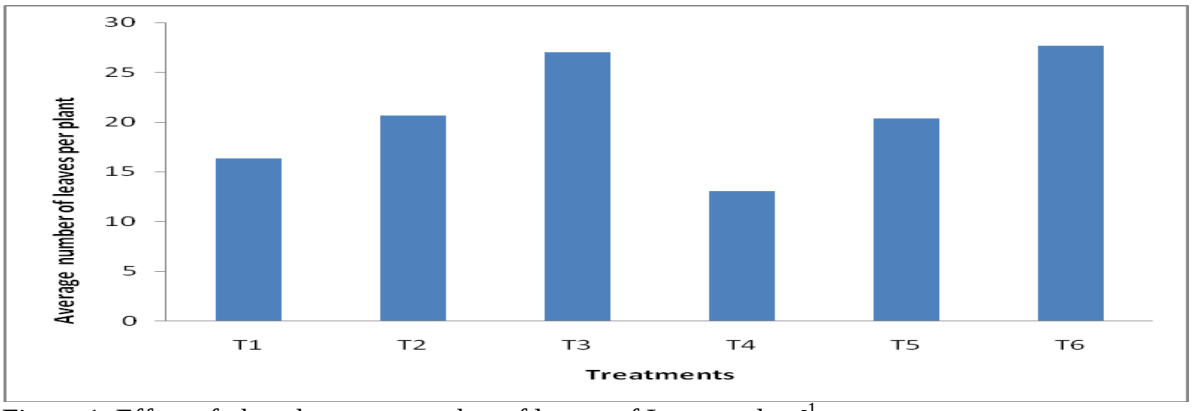

Figure 1. Effect of phosphorus on number of leaves of Lettuce plant^{-1}.

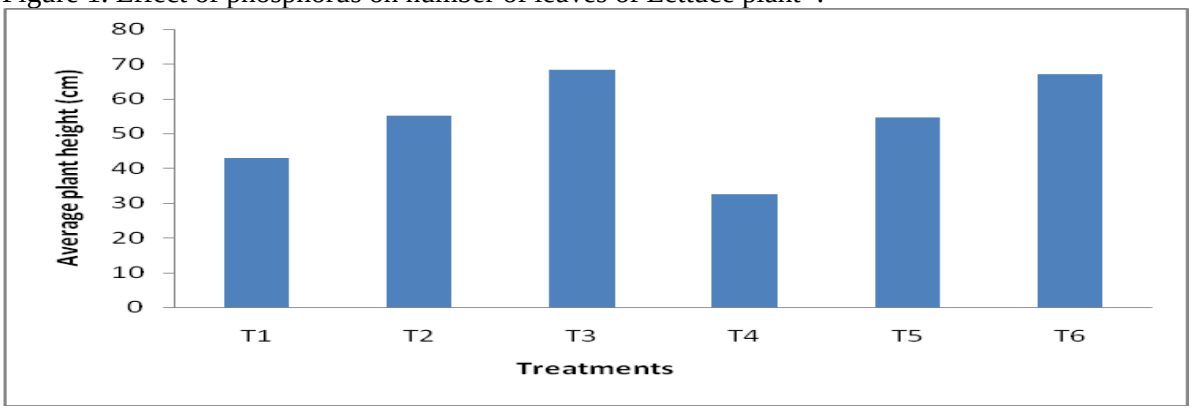

Figure 2. Effect of phosphorus levels on plant height of two cultivars of Lettuce.

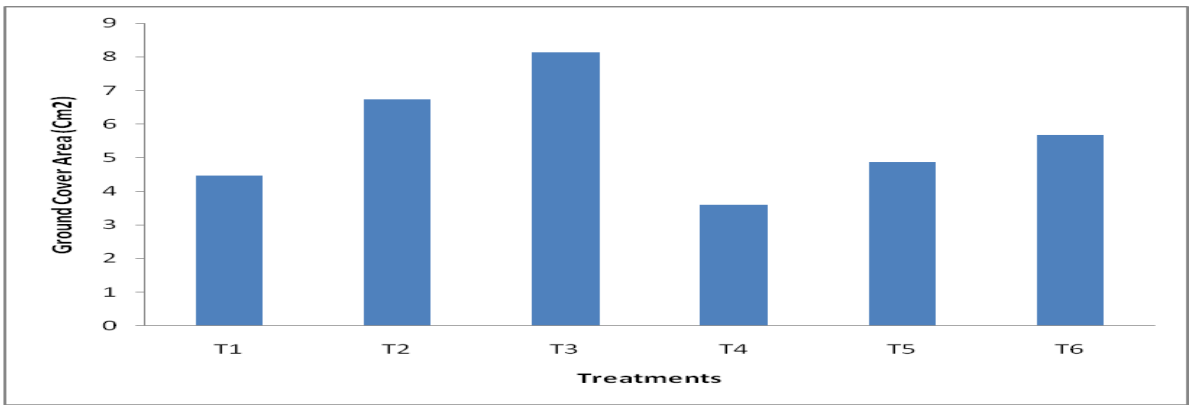

Figure 3. Effect of phosphorus on ground cover of Lettuce cultivars.

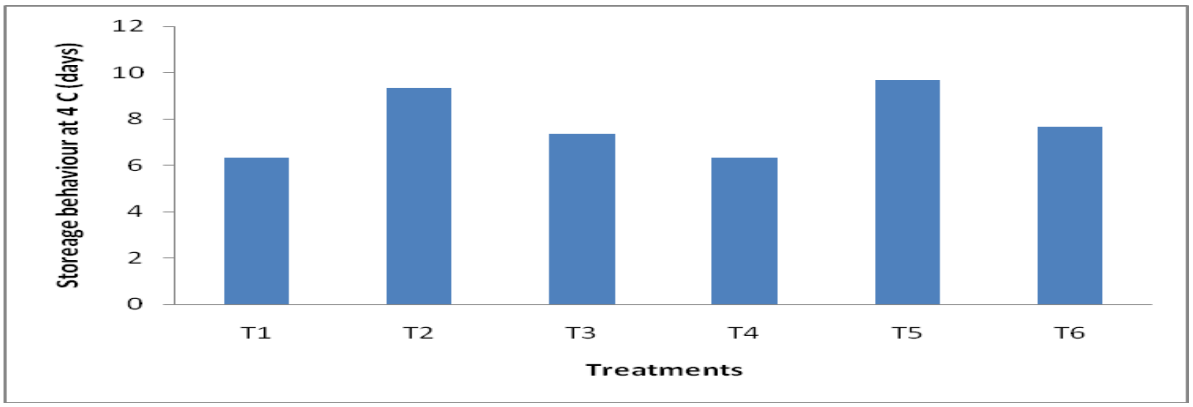

Figure 4. Effect of phosphorus on storage behavior at 4ºC temperature (days).

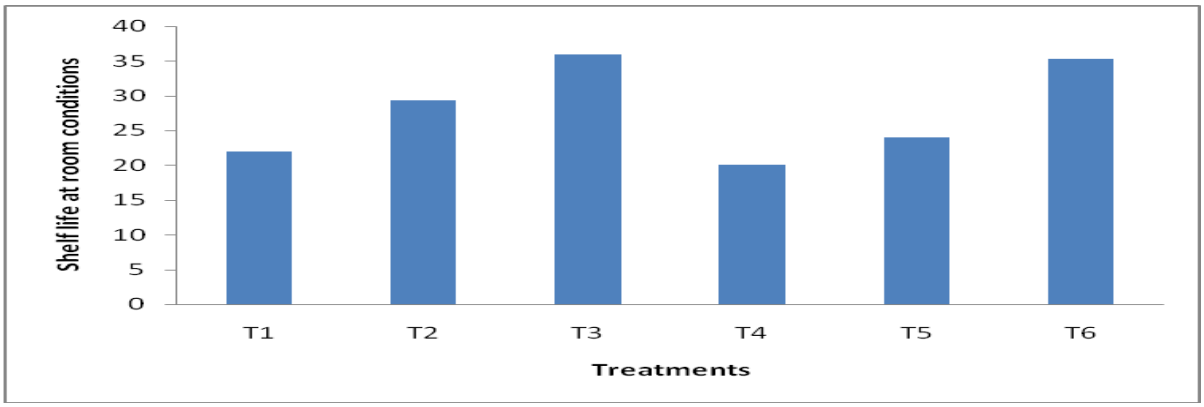

Figure 5. Effect of phosphorus levels on shelf life of Lettuce at room temperature.

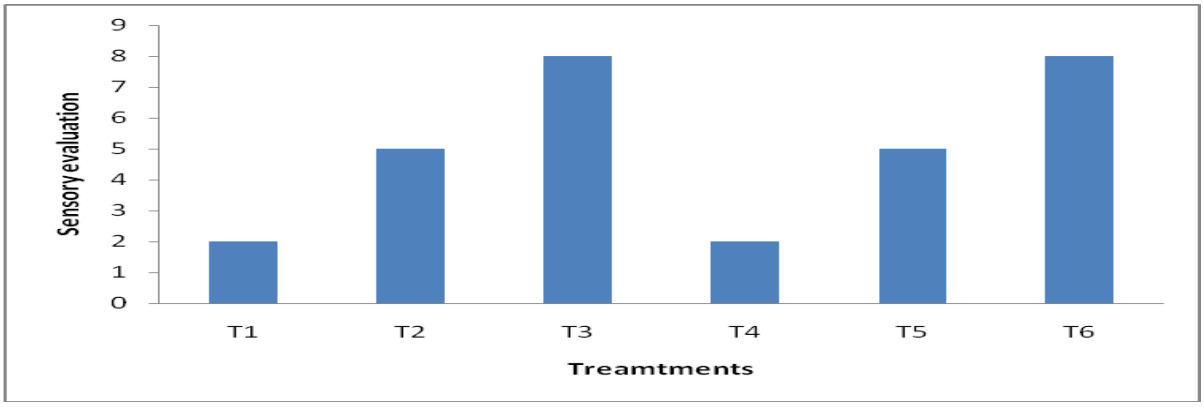

Figure 6. Effect of phosphorus on sensory evaluation for taste, crispiness and color of Lettuce.

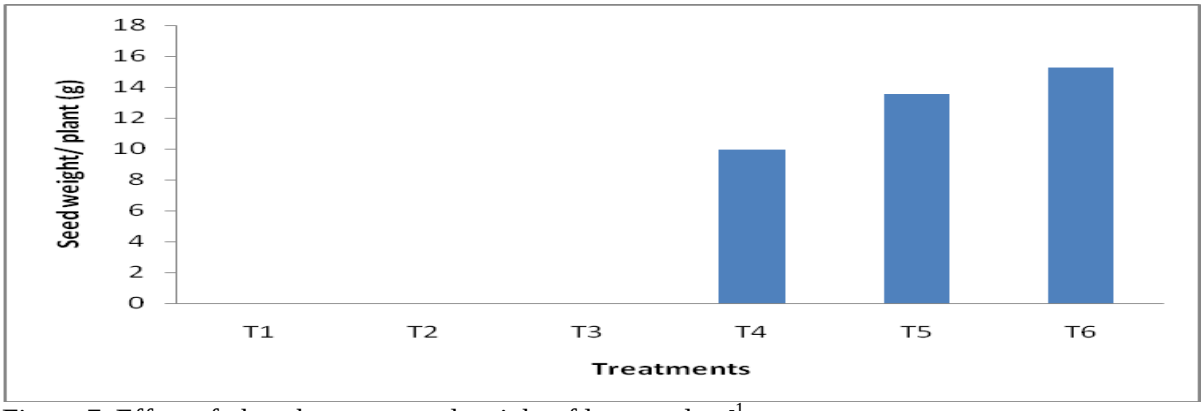

Figure 7. Effect of phosphorus on seed weight of lettuce plant^{-1}.