RESEARCH ARTICLE Indian Journal of Agricultural Research, Volume 55 Issue 5: 542-548 (October 2021)

Bed Planting Techniques Improved Crop Yield by Efficient use of Added Nitrogen Fertilizer

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10.18805/IJARe.A-599

ABSTRACT

Background: Nitrogen fertilizer is imperative for rice and wheat growth and dry matter yield as compare to other macronutrients. Nitrogen is also added in high amount in every one of rice and wheat cultivation method. Effective uptake of added nitrogen by crops from soil supports in increasing crop growth and dry matter yield. Best N fertilizer utilization is indispensable for improving crop growth and to decrease environmental pollution.

Methods: A comparison of the utility of nitrogen fertilizer usage by plants in wheat and rice crops grown on beds and flat land was planned in the current investigation. Beds were manufactured with bed planter machine. The plant samples were collected, dried and digested with acid for mineral nutrients analysis after harvesting the crops.

Result: The results showed that the addition of N fertilizer (80 kg / ha) to the bed produced at par yield (4.51 t / ha) as obtained by an addition of 120 kg N / ha in flat sowing. Planting of rice on bed plus furrow and adding N (100 kg / ha) to the prescribed dosage of N (150 kg / ha) in flat sowing produced at par yield. It concludes that by planting crops on beds without loss in yield, higher use of N fertilizer in crops can be minimized. Thus, bed planting strategies effectively and indirectly minimize nitrous oxide emissions from applied nitrogen fertilizers in wheat and rice crop fields through increasing the usage of added N fertilizer through plants.

Key words: Bed planting, Grain yield, Nitrogen contents, Rice, Wheat.

INTRODUCTION

A big cause of greenhouse gases (GHG) emissions into the atmosphere has historically been grain growing agricultural activities. Global warming is a proven reality and GHG emissions are projected to be the main causes of climate change due to humans and agriculture practices (IPCC, 2013; Ahlawat and Kaur, 2015). Nitrogenous (N) fertilizers play a major role in increasing the production of crop biomass and grain yields. Injudicious and indiscriminate application of N fertilizer has therefore led to food, soil and water contamination in many crops (Chaudhuary *et al*., 2020). Reducing undue N pollution and damages in the 21[st] century poses a significant environmental threat (Wightman, 2015). Participation of Pakistan is invaluable for worldwide efforts to decrease N fertilizer-related GHG pollution, as Pakistan is the agricultural country and uses a large amount of N fertilizer to grow crops. Nitrous oxide (N_2O) is known as a significant source of GHG and induces 298 times greater global warming compared to CO_2 (IPCC, 2013). As opposed to other macronutrients, nitrogen fertilizer is imperative for rice and wheat growth and dry matter yield. Nitrogen is also strongly applied to both of the rice and wheat cultivation methods (Snyder *et al*., 2009; Bond *et al*., 2008; Singh *et al.*, 2014; Majeed *et al*., 2017). The successful absorption of added nitrogen by soil crops promotes the production of dry matter in growing crop growth. Usage of the best N fertilizer is important to improve crop growth and reduce environmental emissions. The lower amount of N fertilizer can result in lower crop biomass, grain quality and for this reason, lower income. If a higher dosage of N fertilizer is used, it leads to a decline in NUE and raises the risk of N depletion in the form of N_2O pollution (Ju *et al*., 2009, Ishaq *et al*., 2001; Xing and Zhu, 2000). One approach to the production of greater grain yield with low nitrogen inputs is to increase NUE (Kukal and Aggarwal, 2003; Naresh *et al*., 2014). Flood irrigation methods for planting wheat and rice on a flat surface resulted in less water and less effective use of fertilizers (Iqbal *et al*. 2005, Mollah *et al*. 2009). Higher wheat plant biomass, dry matter yield and fertilizer usage efficacy is demonstrated by bed and furrow irrigation techniques (Majeed *et al*., 2015). N fertilizer addition can

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How to cite this article: Majeed, A., Niaz, A., Sameen, A., Ahmad, H.B., Younus, M., Aftab, M. and Arif, M. (2021). Bed Planting Techniques Improved Crop Yield by Efficient use of Added Nitrogen Fertilizer. Indian Journal of Agricultural Research. 55(5): 542-548. DOI: 10.18805/IJARe.A-599.

Submitted: 25-09-2020 **Accepted:** 27-03-2021 **Online:** 22-04-2021

have a direct effect on crop yields and GHG emissions (Liang *et al*., 2013; Li *et al*., 2011; Zou *et al*., 2005). Different strategies such as controlled or gradual release of urea and various nitrification inhibitors are used to improve NUE, yield crops and limit GHG emissions (Majumdar, 2003). The aim of this experiment was to increase NUE with various application rates of nitrogen fertilizer under bed and flat planting techniques and to minimize indirect nitrous oxide emissions from cultivated fields.

MATERIALS AND METHODS

Field experiment was carried out at Soil Chemistry Section, Ayub Agricultural Research Institute, Faisalabad Pakistan. Weather data presenting mean monthly maximum temperature and total rainfall during experimental period of wheat and rice crop showed fluctuations (Fig 7). The collected soil sample was air dried, grinded and passed through the 02 mm sieve. Finally the sample was analyzed according to different soil characteristics (Table 1). Using commonly used laboratory techniques as described in the U.S. Lab Salinity (1954) and Page (1982) soil characteristics were assessed. Electrical conductivity (EC) and pH were assessed by adding soil at 1:5, soil: water, ratio to deionized water (Nelson and Sommers, 1982). Available soil P (Olsen *et al*., 1954) and extractable K (Rowell, 1994). Using the hydrometer method described by Bouyoucos (1962), particle size analysis was carried out and the values obtained from soil particles were plotted against the texture triangle of the soil texture class (Table 1). Following the traditional land planning, beds were manufactured with machine to plant beds. Wheat crop seeds (Photographs A and B) and rice nursery seeds (Photographs C and D) were grown on the flat surface and in rows / lines on the bed. Every plot was harvested randomly from nine square meters of land. The plant samples were collected, dried and digested with acid for analysis after harvesting the crops (Jackson, 1962). In plant samples phosphorous was calculated using a colorimetric technique using a spectrophotometer (IRMECO-U-2020). After calibration, samples were analyzed with a 410 nm wavelength spectrophotometer. The absorbed light rate was used in plant samples to show the concentration of P (Allen *et al*., 1986). To test potassium, a flame-photometer was used. A series of standards for drawing up a standard curve (0, 10, 20, 30, 40 and 50 ppm) was prepared. The flame photometer K values were associated with the standard curve and the corresponding total quantity was calculated (Ryan *et al*., 2001). The test for nitrogen was performed using the Kjeldahl process (Jackson, 1962). All treatment was replicated three times and Statistics 8.1 software was used to evaluate statistical data (Steel and Torrie, 1997).

RESULTS AND DISCUSSION

Data revealed (Fig 1) that adding N (80 kg/ha) to the bed provided a non-significant yield (4.51 t/ha) of N (120 kg/ha) in flat sowing (4.63 t/ha) as recommended. The rising application of nitrogen (up to 120 kg/ha) on beds substantially increased the crop yield (5.1 t/ha) than the yield of the traditional flat wheat sowing system by broad casting (4.63 t/ha). It revealed that with bed planting of

Table 1: Soil physicochemical properties.

Experiment	pH_s	EC_e (dS m^{-1})	O.M (%)	Av. P (mg kg^{-1})	Av. K (mg kg^{-1})	Texture
Wheat experiment	8.11	1.57	0.67	8.74	224	Sandy clay loam
Rice experiment	8.17	1.64	0.62	9.34	212	

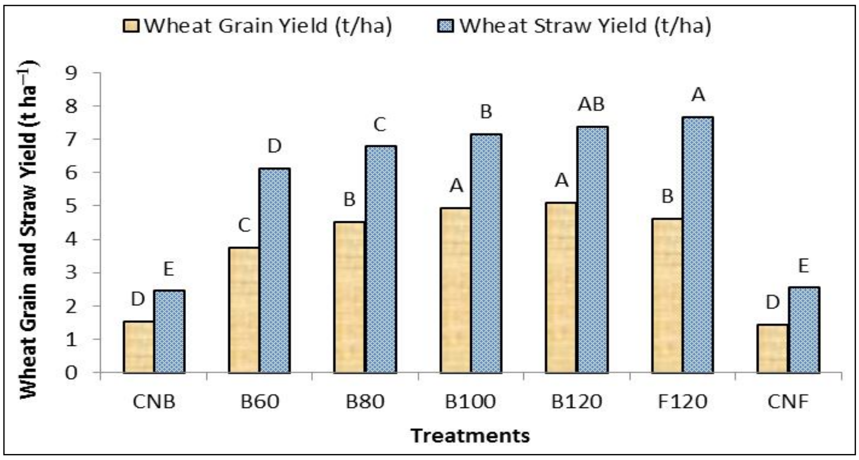

Fig 1: Wheat grain and straw yield (t ha^{-1}) planted on beds and flat soil surface.

Note: T1= CNB (Control bed planting), T2= B60 (Bed planting N@60 kg/ha), T3= B80 (Bed planting N@80 kg/ha), T4= B100 (Bed planting N@100 kg/ha), T5= B120 (Bed planting N@120 kg/ha), T6= F120 (Flat planting N@120 kg/ha), T7= CNF (Control flat planting). According to the LSD test, dissimilar letters suggest substantial difference between treatments at p≤0.05.

wheat, around 1/3 of N fertilizer can be saved. Data (Fig 1) on straw yield showed that the maximum straw yield (7.66 t/ha) was achieved in flat sowing with 120 kg/ha addition of nitrogen. Results concerning the yield of rice paddy (Fig 2) showed that the transplantation of rice on bed plus furrows and 100 kg/ha N addition yielded a higher yield (3.91 t/ha) as obtained by the prescribed dose of N (150 kg / ha) addition in traditional flat transplantation (3.74 t/ha), both of which were equal to each other but substantial than all other levels of nitrogen. Raised beds offered favorable physical and chemical soil conditions for growing plant roots, increased plant use of nitrogen fertilizers and provided superior yields of wheat and rice grains as compared to flat methods (Naresh *et al*., 2014; Majeed *et al*., 2015). Higher yields of wheat and rice grain in bed techniques have been recorded due to higher nutrient uptake (Majeed *et al*., 2017). The water moves from furrow to up bed in the bed sowing process, which increases crop grain yield due to higher nutrient transport and uptake by crop compared to the flat process (Hobbs and Gupta 2003; Farooq *et al*., 2009). Data on the nutrient content of wheat leaves at the booting stage (Fig 3) showed that maximum N concentration (2.81 per cent) was observed when nitrogen was applied @ 120 kg/ha to the bed, which was not significant when 100 kg/ha of nitrogen was added to the beds, whereas it was substantial when nitrogen was applied @ 60 when planting in the bed and 120 kg/ha while sowing flat (Fig 3). Maximum P content (0.20%) was observed during treatment when nitrogen (100 kg/ha) was added to the bed which was non-significant when 120 kg/ha N was added to the flat and bed sowing,

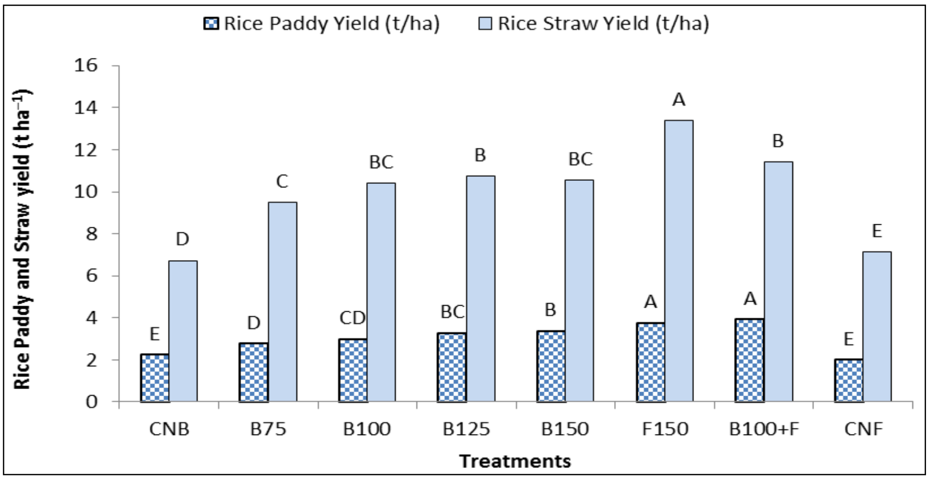

Fig 2: Rice paddy and straw yield (t ha^{-1}) planted on beds and flat soil surface.

Note: T1= CNB (Control bed planting), T2= B75 (Bed planting N@75 kg/ha), T3= B100 (Bed planting N@100 kg/ha), T4= B125 (Bed planting N@125 kg/ha), T5= B150 (Bed planting N@150 kg/ha), T6= F150 (Flat planting N@150 kg/ha), T7= B100+F (Bed+Furrow planting N@100 kg/ha), T8= CNF (Control flat planting). According to the LSD test, dissimilar letters suggest substantial difference between treatments at p≤0.05.

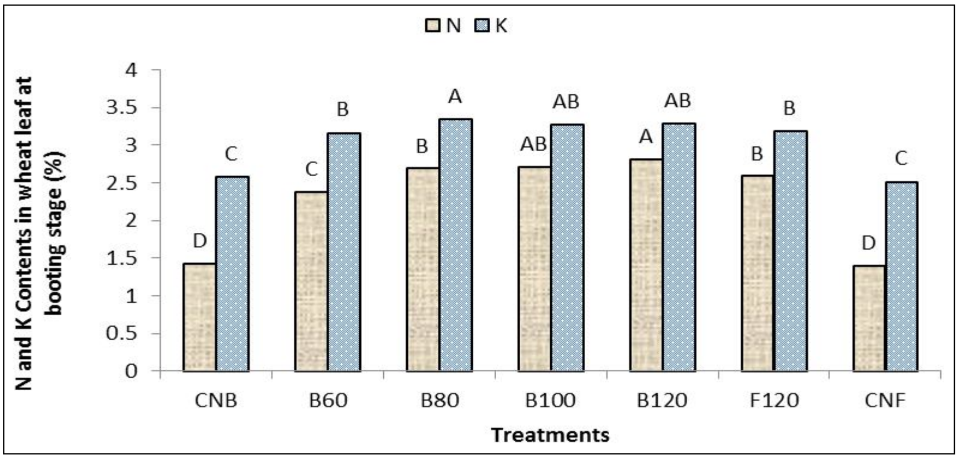

Fig 3: Nitrogen and Potassium contents (%) in wheat leaf at booting stage.

Note: T1= CNB (Control bed planting), T2= B60 (Bed planting N@60 kg/ha), T3= B80 (Bed planting N@80 kg/ha), T4= B100 (Bed planting N@100 kg/ha), T5= B120 (Bed planting N@120 kg/ha), T6= F120 (Flat planting N@120 kg/ha), T7= CNF (Control flat planting). According to the LSD test, dissimilar letters suggest substantial difference between treatments at p≤0.05.

while nitrogen was significant when 60 and 80 kg/ha were added to the beds respectively (Fig 4). Data on N, P and K paddy contents (Fig 5 and 6) showed that the highest N concentration (1.47%) was observed when nitrogen (150 kg/ha) was added to the bed, which was not significant when 100 kg/ha of nitrogen was added to the bed (1.36%), while the addition of nitrogen (150 kg/ha) during flat transplantation was significant. A maximum P content was observed (0.22%) where nitrogen (100 kg/ha) was added to the bed but was equal to other levels of nitrogen, while significant over control (Fig 6). As nitrogen (125 kg/ha) was added to the bed, the highest potassium concentration (0.34%) was noted, which was at par with the T4 and T5 treatments but was substantial over control.

In the bed process, the higher nitrogen content in wheat leaves and rice paddy was correlated with superior crop biomass and slight loss of added N fertilizer. Greater use of N fertilizer by crop was found in the bed system (Jat *et al*., 2011; Majeed *et al*., 2017). Due to good mineralization of applied and indigenous soil nutrients, higher nitrogen utilization and crop yield were observed in the bed plantation process. In bed method plant roots take up efficiently added N fertilizer than flat method, even if N fertilizer was added in lower amounts indicating decrease in nitrogen losses (Mollah *et al*., 2009 and Jat *et al*., 2011).

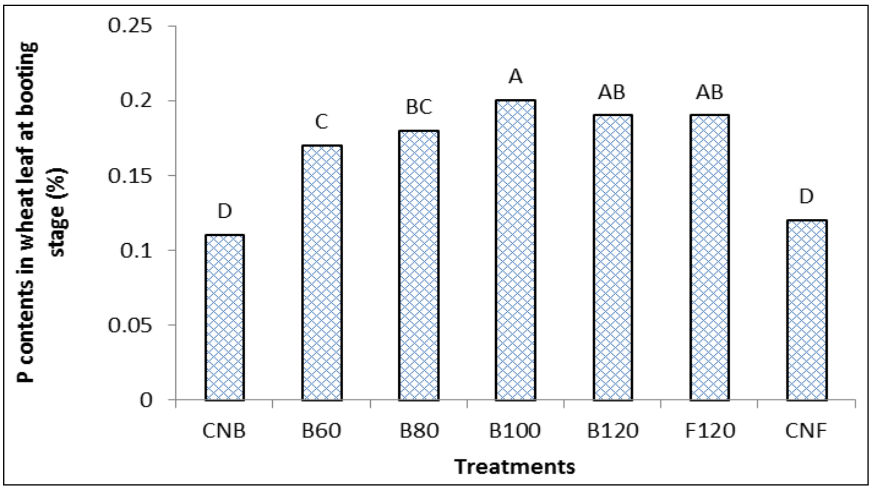

Fig 4: Phosphorus contents (%) in wheat leaf at booting stage.

Note: T1= CNB (Control bed planting), T2= B60 (Bed planting N@60 kg/ha), T3= B80 (Bed planting N@80 kg/ha), T4= B100 (Bed planting N@100 kg/ha), T5= B120 (Bed planting N@120 kg/ha), T6= F120 (Flat planting N@120 kg/ha), T7= CNF (Control flat planting). According to the LSD test, dissimilar letters suggest substantial difference between treatments at $p \leq 0.05$.

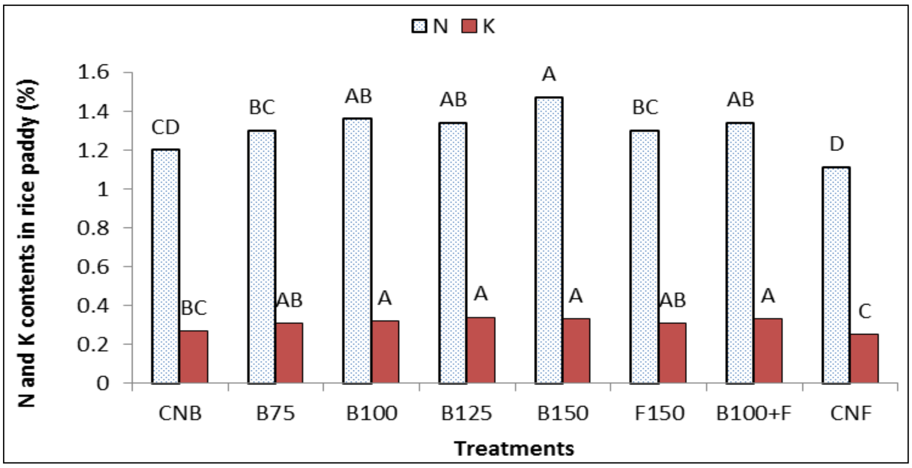

Fig 5: Nitrogen and Potassium contents (%) in rice paddy.

Note: T1= CNB (Control bed planting), T2= B75 (Bed planting N@75 kg/ha), T3= B100 (Bed planting N@100 kg/ha), T4= B125 (Bed planting N@125 kg/ha), T5= B150 (Bed planting N@150 kg/ha), T6= F150 (Flat planting N@150 kg/ha), T7= B100+F (Bed+Furrow planting N@100 kg/ha), T8= CNF (Control flat planting). According to the LSD test, dissimilar letters suggest substantial difference between treatments at $p \leq 0.05$.

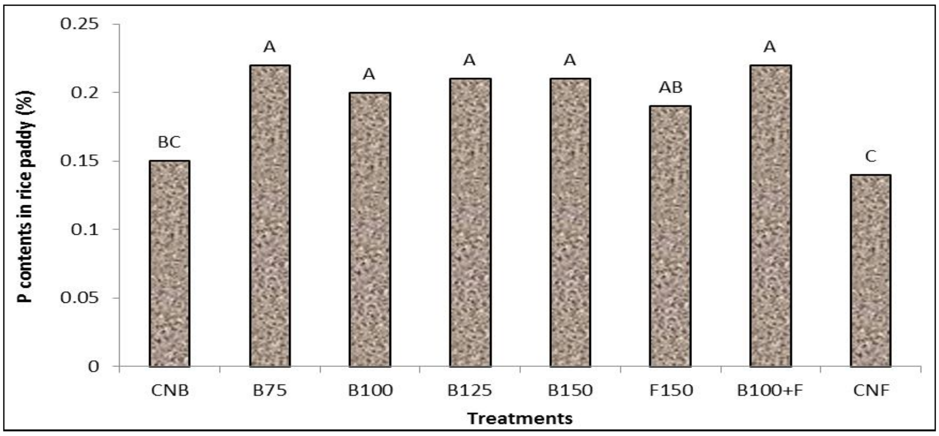

Fig 6: Phosphorus contents (%) in rice paddy.

Note: T1= CNB (Control bed planting), T2= B75 (Bed planting N@75 kg/ha), T3= B100 (Bed planting N@100 kg/ha), T4= B125 (Bed planting N@125 kg/ha), T5= B150 (Bed planting N@150 kg/ha), T6= F150 (Flat planting N@150 kg/ha), T7= B100+F (Bed+Furrow planting N@100 kg/ha), T8= CNF (Control Flat planting). According to the LSD test, dissimilar letters suggest substantial difference between treatments at $p \leq 0.05$.

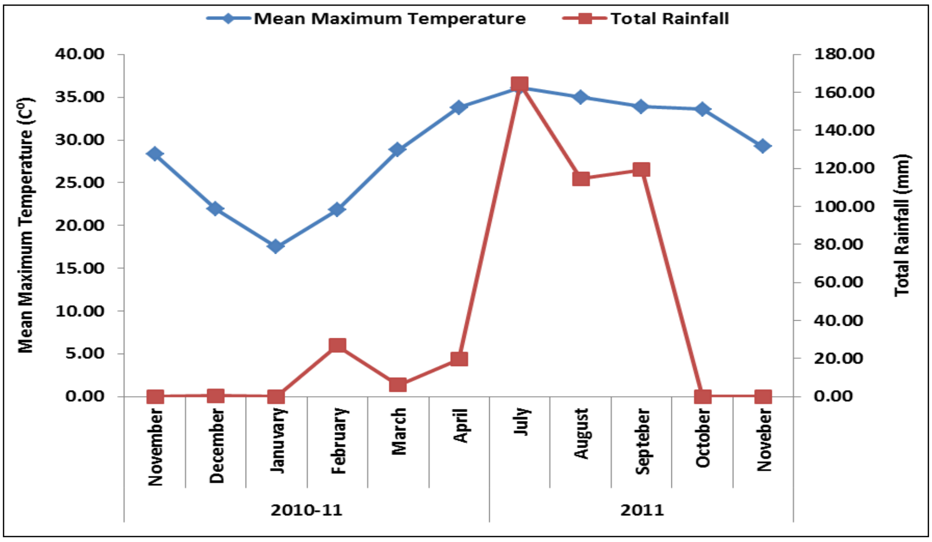

Fig 7: Weather data presenting mean monthly maximum temperature and total rainfall during experimental period of wheat and rice crop.

Photograph (A): Growth of wheat crop on bed.

Photograph (B): Wheat crop on bed at early stage.

Photograph (C): Rice crop on beds at early stage.

Photograph (D): Rice crop on beds at harvesting stage.

CONCLUSION

Bed planting techniques increase the nitrogen content of crop plants and achieve higher wheat and rice grain yields at a lower fertilizer rate compared to flat sowing. It also suggests that bed planting technologies indirectly minimize greenhouse gas emissions from nitrogen by increasing the performance of the nitrogen-related fertilizer applied in wheat and rice crops. Therefore, in order to solve the issue of global warming by increased use of nitrogen fertilizer in crops and lower efficiency of use of N, in future wheat and rice crops should be planted on beds to improve fertilizer utilization by crops.

ACKNOWLEDGEMENT

We are very thankful to Farm Manager of Soil Chemistry Section, Ayub Agricultural Research Institute Faisalabad, for providing the field area for this research work and also to the reviewers for the improvement of this manuscript.

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