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*Research Article*

# Dry Matter Accumulation and Nutrient Uptake by Wheat (*Triticum aestivum* L.) under Poplar (*Populus deltoides*) Based Agroforestry System

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Wheat (*Triticum aestivum* L.) being grown with association of boundary plantations of poplar (*Populus deltoides* M.) has to face competition for water and nutrients uptake. Field experiment was carried to study the dry matter accumulation pattern and nutrients uptake by wheat grown in association with boundary plantations of three- and four-year-old poplar plants under irrigated condition. Dry matter accumulation of wheat declined considerably due to presence of poplar tree line during all the growth stages as compared to pure crop. Maximum reduction in dry matter accumulation in wheat was observed near the tree line (0–3 m) under both three- as well as four-year-old plantation (21.1 and 17.8 per cent under three- and four-year-old trees, resp.) which tapered off beyond that, but synergetic effect caused by existence of trees increased dry matter significantly between 3–6 m distance and 6–9 m distance under both three- as well as four-year-old plantation. Similarly, minimum concentration of nutrients (nitrogen, phosphorus, and potassium) as well as their uptake in wheat plants was observed near the tree line (0–3 m) and increased subsequently with increase in distance from tree line.

## 1. Introduction

Plantation of poplar (*Populus deltoides* M.) tree on the boundary of the agricultural fields is becoming popular among the farmers in Northern India. Wheat (*Triticum aestivum* L.) is one of the most important winter crops being grown in association with the plantation and one of the important agroforestry systems of the area [1, 2]. Since, agroforestry system involves mixture of species, they should share for resource utilization. Uptake of nutrients depends on the number, surface area, distribution, and effectiveness of the root system of individual species in the mixture. Being a perennial, tree root systems have the chance to explore larger area, both laterally and vertically and exploit zones of rich localized supply of nutrient with a result that the growth of the smaller understory species may be inhibited by competition for nutrients. It has been indicated that roots of fast-growing trees may extend laterally by at least 2 m each year [3]. Poplar is a fast-growing tree and has ability to provide substantial production [4, 5]. Toky and Bisht [6] noted that 60–80 per cent of the roots of 6-year-old poplar were present in the upper soil layer (0–45 cm). However, maximum fine roots were concentrated in 15–30 cm soil depth. Thus, the bulk of roots were quite close to surface, and therefore, root competition with agricultural crops is likely. Fast-growing and short-rotation trees deplete the soil more as compared to slow-growing and long-duration trees [7]. Nandal and Bisla [8] and Singh and Sharma [9] marked the competition for moisture and nutrient by the shallow poplar (*Populus deltoides* M.) roots in February and March in poplar-oat agroforestry system. Wheat is one of the most important *Winter* crops being grown in association with boundary plantations of poplar in India. Uptake of nutrient by wheat may differ from that of pure agricultural system due to competition for nutrients when grown in association with poplar. The aim of this study was to determine the pattern

of dry matter accumulation and nutrients uptake by wheat when grown in association with poplar boundary plantations under irrigated condition.

## 2. Material and Methods

*2.1. Location.* A field study was conducted for two years at the Research Farm of J.V. College, Baraut, U.P., India. Baraut is situated at a height of 230 m above mean sea level, intersected by 29°6′N latitude and 77°60′E longitude. The soil of the experimental area varied in texture from sandy clay loam to loam and was low in nitrogen and phosphorus with pH varying from 6.5 to 7.1. The average annual rainfall of the area is 652 mm out of which more than 84% is received during monsoon season (July to September). Summers are very hot and windy with maximum temperature during crop growth period varying from 37.7 to 17.0°C and minimum from 23.4 to 4.2°C.

*2.2. Experimental Detail.* Wheat variety HD-2285 was sown in an agricultural field having a single row boundary plantation (60 m long) of three-year-old poplar (*Populus deltoides*, clone "G-3") trees, already existing (3.5 m tree to tree distance) and oriented in northeast and southwest direction. Summary statistics revealed to growth characters of poplar tree is given in Table 1. Standard package of practices was adopted for raising the wheat crop. The wheat field was flood-irrigated five times during the growing season. To take the observations, 10 m wide and 15 m long strip (one replication) was divided into five segments. Each segment had 10 m (along the tree line) × 3 m (perpendicular to the tree line) area. Area beyond 15 m was treated as unaffected or control. Thus, there were six distances (0–3, 3–6, 6–9, 9–12, 12–15 m, and control, no effect) from where observations were recorded. To avoid the variation, 10 m space (3 trees) on either side of the tree line (60 m long) was left as border and rest space (40 m) divided into 4 equal parts. Thus, in all, there were 24 plots, each measuring 10 × 3 m area, in the experiment. Statistical analysis was done as per standard procedure [10].

*2.3. Dry Matter Accumulation.* Plants from 0.5 m row length were selected randomly from the area marked for the purpose of dry matter estimation. Plants were cut at the soil surface at 30, 60, and 90 days and at maturity. Samples were sun-dried and finally oven-dried at 70°C to a constant weight for estimation of dry matter accumulation and ground to 20 mesh and preserved for subsequent chemical analysis.

*2.4. Nutrient Uptake.* Plant samples collected for estimation of dry matter accumulation at 30, 60, and 90 days after sowing analysed for N, P, and K. At harvest, grain and straw samples were analysed separately. N, P, K in plant biomass were determined by Micro-Kjeldahl methods of Chopra and Kanwar [11], Olsen et al. [12] and Jackson [13], respectively.

Total uptake of N/P/K was calculated separately by the following formula:

$$\text{Uptake of N/P/K}\left(\text{kg ha}^{-1}\right) = \frac{\text{N\%P\%K\%} \times \text{dry matter}\left(\text{kg ha}^{-1}\right)}{100}. \quad (1)$$

## 3. Results

*3.1. Dry Matter Accumulation.* Observations on dry matter accumulation were taken at successive stages of crop growth and data on basic changes of dry matter accumulation are presented in Table 2. During initial growth stages (at 30 days) dry matter of wheat decreased considerably due to presence of poplar tree line. Maximum loss in dry matter in wheat (21.1 and 17.8 per cent under three- and four-year-old trees, resp.) was observed near the tree line (0–3 m) which tapered off beyond that. On an average, 19 per cent decrease and 30 per cent increase was observed over control at 3 and 9 m distance, respectively. Trends were continued at 60-day stage, but significant decrease was noticed only up to 3 m distance. Irrespective of age, average reduction over control at this stage was 50.4 per cent at 0–3 m, 11.2 per cent at 3–6 m, 9.6 per cent at 6–9 m, 8 per cent at 9–12 m, and 5.8 per cent at 12–15 m distance from tree line. With further advancement of season variations in dry matter production, caused by tree line, narrowed down considerably in both the years. Significantly lower dry matter (6660 kg ha$^{-1}$) was produced up to a distance of 3 m with three-year-old plantation which extended up to 6 m (6500 and 7333 kg ha$^{-1}$ between 0–3 and 3–6 m distance, resp.) with four-year-old plantation.

At crop maturity competition at interface significantly reduced the dry matter production between 0 and 3 m distance in both the years, but synergetic effect caused by existence of trees increased dry matter significantly between 3–6 m distance and 6–9 m distance with three- and four-year-old plantations, respectively. However, significant reduction (19.8%) in dry matter was recorded with four year old plantation near the tree (0–3 m), whereas reduction was nonsignificant with three-year-old plantation. Irrespective of distance, on an average yield of dry matter was increased by 0.8 per cent between 0 and 15 m distance as compared to control.

*3.2. Nutrient Uptake Pattern.* Data on phasic changes related to uptake of nutrients are presented in Table 3 and Figure 1. At 30-day growth stage, minimum concentration of nutrients (nitrogen, phosphorus, and potassium) in wheat plants as well as their uptake was observed near the tree line (0–3 m); however, maximum was observed in control plots and increased subsequently with increase in distance from tree line in both the years. Minimum nitrogen uptake of 3.2 and 3.0 kg ha$^{-1}$ and maximum of 7.0 and 7.3 kg ha$^{-1}$ in 0–3 m and 6–9 m distance from tree line were analyzed in three- and four-year-old plantations, respectively. Nitrogen concentration varied between 2.9 to 4.5 per cent and 2.5 to 4.5 per cent in the sample.

Table 1: Summary statistics of growth characters of *poplar* trees during study period.

| Growth characters | 3 years* | | | 4 years* | | |
|---|---|---|---|---|---|---|
| | Minimum | Maximum | Mean | Minimum | Maximum | Mean |
| Height (m) | 9.3 | 11.6 | 10.3 | 11.5 | 14.5 | 12.9 |
| DBH (cm) | 9.1 | 16.0 | 12.1 | 10.5 | 21.6 | 17.1 |
| Crown diameter (m) | 4.8 | 5.8 | 5.1 | 5.5 | 6.9 | 6.1 |
| MAI of DBH (cm) | 3.0 | 5.3 | 4.0 | 2.6 | 5.7 | 4.3 |

DBH: diameter at breast height; MAI: mean annual increment; *age of poplar trees.

Table 2: Periodic changes in dry matter (kg ha$^{-1}$) accumulation of wheat crop at different distance from poplar tree line.

| Distance from tree line (m) | Days after sowing | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 30 | | 60 | | 90 | | At harvest | |
| | 3 years* | 4 years* | 3 years* | 4 years* | 3 years* | 4 years* | 3 years* | 4 years* |
| 0–3 | 110.7 | 120.3 | 1002 | 1027 | 6660 | 6500 | 8475 | 7500 |
| 3–6 | 173.5 | 139.0 | 1800 | 1830 | 7120 | 7333 | 10786 | 9363 |
| 6–9 | 180.5 | 192.5 | 1830 | 1868 | 7030 | 7720 | 10192 | 10823 |
| 9–12 | 150.3 | 155.0 | 1870 | 1890 | 7270 | 7680 | 9486 | 9388 |
| 12–15 | 153.1 | 155.1 | 1920 | 1932 | 7528 | 7790 | 9438 | 9047 |
| Control** | 140.3 | 146.4 | 2035 | 2060 | 7550 | 7830 | 9398 | 9353 |
| LSD ($P = 0.05$) | 5.8 | 7.3 | 375 | 252 | 590 | 380 | 948 | 752 |

* Age of the trees; **recorded 15 m away from tree line.

Table 3: Periodic uptake of nutrients (kg ha$^{-1}$) by wheat at different distances from poplar tree line.

| Distance from tree line (m) | Nutrients uptake (kg ha$^{-1}$) | | | | | |
|---|---|---|---|---|---|---|
| | N | P | K | N | P | K |
| | 3 years | | | 4 years | | |
| | 30 days after sowing | | | | | |
| 0–3 | 3.2 | 0.48 | 4.0 | 3.0 | 0.36 | 4.1 |
| 3–6 | 6.6 | 0.68 | 6.3 | 4.0 | 0.56 | 5.0 |
| 6–9 | 7.0 | 0.70 | 7.2 | 7.3 | 0.71 | 7.3 |
| 9–12 | 6.7 | 0.75 | 6.0 | 7.0 | 0.70 | 6.5 |
| 12–15 | 6.9 | 0.77 | 5.8 | 7.0 | 0.73 | 6.7 |
| Control* | 6.4 | 0.76 | 5.3 | 6.7 | 0.70 | 6.3 |
| | 60 days after sowing | | | | | |
| 0–3 | 22.3 | 2.3 | 28.1 | 21.3 | 2.3 | 31.8 |
| 3–6 | 40.5 | 4.3 | 48.6 | 39.9 | 4.2 | 54.9 |
| 6–9 | 42.5 | 5.8 | 48.5 | 43.0 | 5.6 | 54.2 |
| 9–12 | 46.2 | 5.8 | 52.7 | 46.5 | 5.9 | 51.0 |
| 12–15 | 47.8 | 6.1 | 54.3 | 47.9 | 6.0 | 54.1 |
| Control* | 51.3 | 6.3 | 57.6 | 51.4 | 6.4 | 57.5 |
| | (2.5) | (0.31) | (2.8) | (2.5) | (0.31) | (2.8) |
| | 90 days after sowing | | | | | |
| 0–3 | 76.6 | 11.3 | 69.9 | 76.7 | 11.7 | 66.3 |
| 3–6 | 86.2 | 10.7 | 71.9 | 90.2 | 12.5 | 77.7 |
| 6–9 | 87.2 | 12.7 | 80.9 | 96.5 | 13.9 | 90.3 |
| 9–12 | 93.1 | 13.1 | 80.0 | 97.5 | 13.8 | 75.3 |
| 12–15 | 96.4 | 13.6 | 82.8 | 98.9 | 13.2 | 75.6 |
| Control* | 98.8 | 14.7 | 84.9 | 99.4 | 13.3 | 78.3 |

* Age of the trees; **recorded 15 m away from tree line; figures in parenthesis are concentration (%) of respective nutrients.

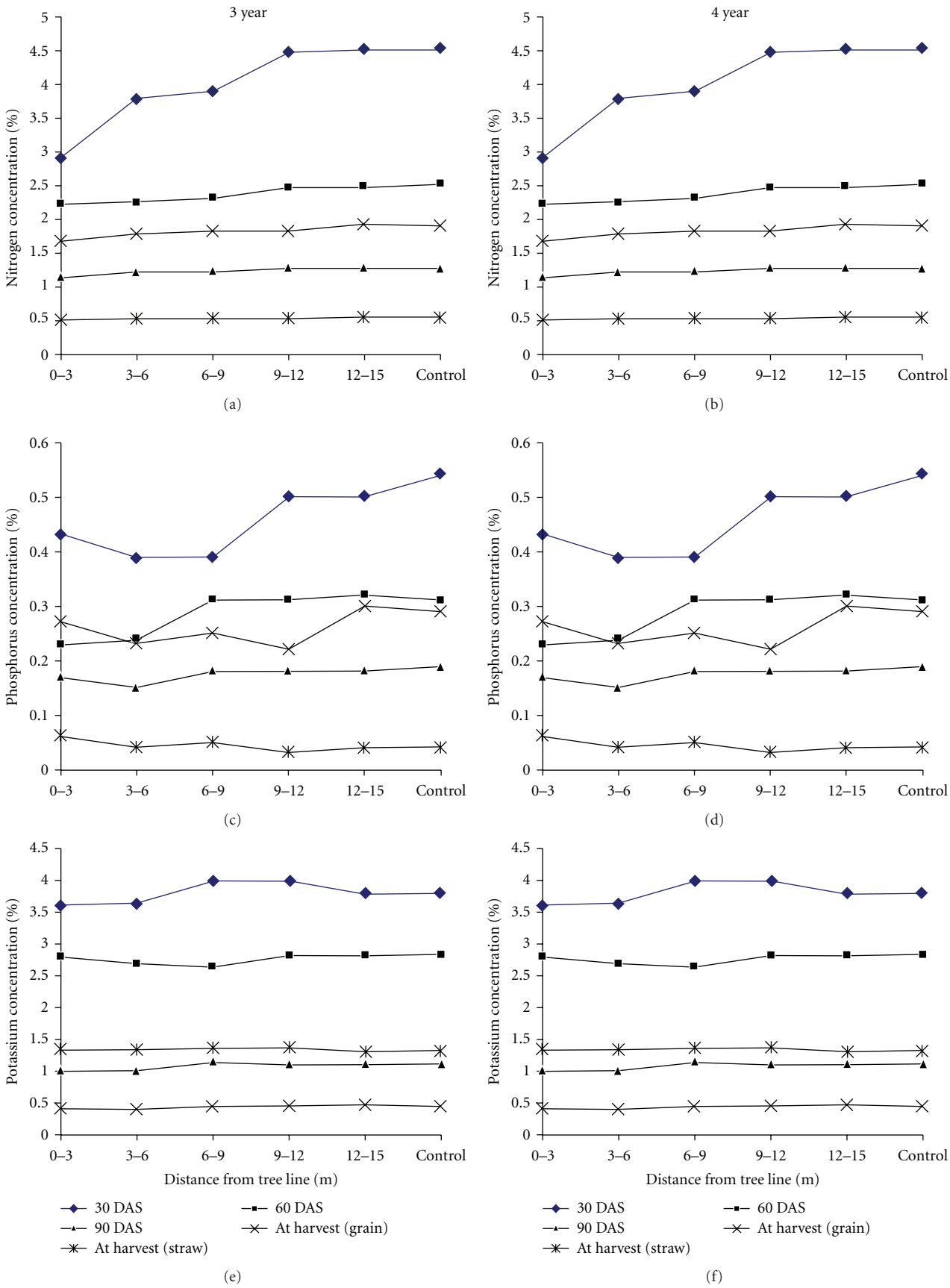


Figure 1: Periodic changes in nutrient concentration (%) of wheat at different distances from poplar tree line.

Phosphorus uptake varied between 0.48 to 0.77 kg ha$^{-1}$ and 0.36 to 0.73 kg ha$^{-1}$ between 0 and 15 m distance from tree line with three- and four-year-old plantations, respectively. Three-year-old plantation reduced phosphorus uptake up to 11.1 per cent which went up to 12.6 per cent in 4-year-old plantation. Following the similar trend of uptake, increase in concentration of phosphorus in wheat plants was a function of distance from tree line in both the years, it ranged between 0.39 to 0.50 per cent and 0.30 to 0.47 per cent between 0 and 15 m distance from tree line with three- and four-year-old plantations, respectively, collected from 0–15 m distance with three- and four-year-old plantations respectively, whereas in control it was 4.5 per cent in both the years. Minimum potassium (4.0 and 4.1 kg ha$^{-1}$ with three- and four-year-old plantations, resp.) was taken up between 0 and 3 m distance, whereas maximum potassium uptake of 7.2 and 7.3 kg ha$^{-1}$ was recorded between 3 and 6 m distance in with three- and four-year-old plantations, respectively. Similarly, concentration of potassium (3.6 and 3.4% with three- and four-year-old plantations, resp.) was minimum near the tree line (0–3 m) and increased between 3 and 9 m distance with three year old plantations only.

Patterns were quite similar at 60-day growth stage to those found during previous period. At this stage maximum uptake of nitrogen (51.3 and 51.4 kg ha$^{-1}$) was recorded from control plots, whereas minimum (22.3 and 21.3 kg ha$^{-1}$) was taken up near the tree line (0–3 m) with three- and four-year-old plantations, respectively. There was a successive increase in nitrogen uptake at each distance away from trees in both the years. Nitrogen concentration in the wheat plants followed the trend similar to that of uptake. Plants from control plot had highest (2.5%) concentration of nitrogen in both the years. Nitrogen concentration varied between 2.2 to 2.5 per cent and 2.1 to 2.5 per cent between 0 and 15 m distances influenced by tree line with three- and four-year-old plantations, respectively. Smallest (2.30 and 2.26 kg ha$^{-1}$ with three- and four-year-old plantations, resp.) amount of phosphorus accumulated by the plants between 0 and 3 m distance from tree line, whereas largest (6.31 and 6.37 kg ha$^{-1}$ with three- and four-year-old plantations, resp.) was taken up by plants form control plots. Plant samples collected from 0–6 m distance show less concentration of phosphorus in both the years which varied between 0.22 and 0.24 per cent. Beyond that concentration was almost same as recorded from control plots in both the years.

Uptake of potassium was reduced by 48.7 and 44.6 per cent near the tree line (0–3 m) with three- and four-year-old plantations, respectively. However, beyond that successive increase in uptake was obtained at each distance away from trees in both the years. Potassium content of wheat plants from 0–6 m and 0–9 m distance was higher with three- and four-year-old plantations, respectively. It varied between 2.9 to 3.0 and 2.9 to 3.1 per cent, respectively. At 90-day growth stage uptake of nutrients appeared to be enhanced between 0 and 9 m distance unlike the previous stages in both the years. Thus, the magnitude of loss in nitrogen uptake between 0 and 9 m distance reduced from 31.6 to 15.7 per cent with three year old plantation and 32.4 to 11.7 per cent with four year old plantation during this stage as compared to 60-day old plants. Similarly, concentration of nitrogen in wheat plants also improved during this growth phase. Improvement in phosphorus uptake between 0 and 9 m distance was observed only in with three year old plantation. Apart from uptake, concentration also improved in this year. But not much improvement was noticed with three year old plantations. Minimum uptake of 10.7 kg ha$^{-1}$ between 3–6 m and 11.7 kg ha$^{-1}$ between 0 and 3 m distance, was recorded with three- and four-year-old plantations, respectively.

Like nitrogen and phosphorus, potassium uptake also improved during this stage. Maximum improvement was recorded between 6 and 9 m distance with four year old plantation where uptake increased 15.4 per cent over control. Similarly, 4.5 and 17 per cent higher concentration of potassium was observed between 3–6 m and 6–9 m distance over control with three- and four-year-old plantations, respectively.

Trend analysed at 90-day stage was continued till maturity of the crop. It resulted in 8.2 and 9.2 per cent higher nitrogen uptake, between 3–6 m and 6–9 m distance with three- and four-year-old plantations, respectively. Thus, maximum nitrogen (124.0 and 127.7 kg ha$^{-1}$) was taken up by wheat crop between 3–6 and 6–9 m distance from tree line with 3- and 4-year-old plantations, respectively.

Improvement in uptake of phosphorus was noticed only with four year old plantation. Uptake of phosphorus enhanced from 2.1 to 7.6 per cent at harvest between 0 and 15 m distance as compared to their respective controls. Similar trend was recorded related to concentration of phosphorus of wheat plant. Higher competition near the tree line (0–3 m) resulted in minimum uptake of potassium (77.3 and 69.0 kg ha$^{-1}$ with three- and four-year-old plantations, resp.). However, maximum uptake (94.9 and 108.2 kg ha$^{-1}$ with three- and four-year-old plantations, resp.) was recorded between 3–6 m and 6–9 m distance. It was observed that total uptake of potassium by wheat crop increased by 7.9 per cent between 3 and 15 m distance in with three-year-old plantation and by 16.1 per cent between 6 and 12 m distance with four year old plantation. No marked differences were observed in concentration of potassium in wheat plants at maturity in both the years. Grain produced by crop near the tree line had minimum quantity of nitrogen (47.2 and 41.8 kg ha$^{-1}$ with three- and four-year-old plantations, resp.). Whereas, synergetic effect of trees caused maximum uptake of nitrogen (57.9 kg ha$^{-1}$ at 3 m and 55.7 kg ha$^{-1}$ at 6 m distance with three- and four-year-old plantations, resp.) (Table 4). Concentration of nitrogen in wheat grain was minimum (1.68 and 1.72% with three- and four-year-old plantations, resp.) between 0 and 3 m distance and tapered off with increase in distance from row of poplar trees.

Phosphorus uptake by wheat grain with three year old plantation was almost similar up to a distance of 9 m and relatively lower than control which varied between 7.5 and 7.7 kg ha$^{-1}$. But with three year old plantations higher uptake was recorded between 3 and 15 m distance than control (7.59 kg ha$^{-1}$) which varied between 7.8 and 8.87 kg ha$^{-1}$. But uptake was minimum (6.53 kg ha$^{-1}$) near the tree line (0–3 m) in the same year. Plants from control had highest

Table 4: Nutrients uptake (kg ha$^{-1}$) by wheat crop at harvest at different distances from poplar tree line.

| Distance from tree line (m) | Nutrient uptake (kg ha$^{-1}$) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | P | K | N | P | K | N | P | K | N | P | K |
| | 3 years | | | | | | 4 years | | | | | |
| | Grain | | | Straw | | | Grain | | | Straw | | |
| 0–3 | 47.2 | 7.6 | 11.2 | 28.3 | 3.1 | 75.9 | 41.8 | 6.5 | 10.6 | 28.4 | 2.5 | 71.5 |
| 3–6 | 57.9 | 7.5 | 13.0 | 39.2 | 3.2 | 101.7 | 50.7 | 8.7 | 12.7 | 39.7 | 2.2 | 87.9 |
| 6–9 | 56.2 | 7.7 | 13.5 | 38.5 | 3.4 | 97.6 | 55.7 | 7.8 | 13.9 | 38.7 | 3.3 | 112.2 |
| 9–12 | 54.3 | 6.5 | 13.1 | 34.6 | 2.1 | 88.6 | 51.7 | 8.4 | 12.0 | 33.0 | 2.8 | 95.7 |
| 12–15 | 57.5 | 8.9 | 13.7 | 34.3 | 2.5 | 83.3 | 55.2 | 8.9 | 11.4 | 33.0 | 2.4 | 84.1 |
| Control* | 56.8 | 8.7 | 13.2 | 34.6 | 2.6 | 84.6 | 57.0 | 7.6 | 12.9 | 35.0 | 2.7 | 87.4 |

* Recorded 15 m away from tree line.

concentration (0.29%) of phosphorus with three year old plantation, whereas with four year old plantation relatively higher concentration was noticed between 3–6 and 9–15 m distance from tree line which varied between 0.30 and 0.31 per cent. Moreover, the concentration of nitrogen in wheat plants was observed between 0 and 6 m distance with three year old plantation, but with four year old plantation maximum concentration was noticed between 0 and 6 m distance.

Maximum uptake of phosphorus by wheat straw was recorded up to a distance of 9 m with three year old plantation which varied between 3.1 and 3.4 kg ha$^{-1}$ as compared to control (2.6 kg ha$^{-1}$). Beyond that uptake was comparatively less which varied between 2.1 and 2.5 kg ha$^{-1}$. With four year old plantation maximum (3.3 kg ha$^{-1}$) and minimum (2.18 kg ha$^{-1}$) uptake of phosphorus was recorded between 6–9 and 3–6 m distance from tree line, respectively. Wheat plants near the tree (0–3 m distance) produced maximum concentration of phosphorus (0.06%) in both the years. Maximum potassium uptake of 101.7 and 112.2 kg ha$^{-1}$ between 3–6 and 6–9 m distance from tree line, respectively, and minimum of 75.9 and 71.5 kg ha$^{-1}$ at 0–3 m distance were analysed with three- and four-year-old plantations, respectively. Higher concentration of potassium was noticed in straw from near the tree line.

## 4. Discussion

Highest reduction in the biomass of wheat near the tree line as compared to control and improvement with increasing distance can be attributed to the severe competition by the tree roots which gets reduced with increase in distance from the tree line. Results are further supported by the findings of Singh et al. [14] and Ding and Su [15] who stated that there is extensive underground competition between the eucalyptus tree and crop near the tree line due to which the development of the roots of wheat suffered badly. Wheat root in 25 m distance from eucalyptus tree was confined to 60 cm layer, as compared 120 cm layer in control. From above, inferences can be drawn for the present study that crop near the tree line suffered in terms of nutrients uptake which though were present in abundance but could not be utilised by the crop because of limited root system and their reduced availability [9, 14]. It was analysed that total nitrogen uptake (grain + straw) ranged between 92.4 and 90.8 kg ha$^{-1}$ between 0 and 3 m distance from the tree line as compared 114.7 to 116.9 kg ha$^{-1}$ recorded in control plots in both plantations. Similarly, total phosphorus uptake was also reduced from 16.0 to 13.6 kg ha$^{-1}$ and from 14.0 to 12.0 kg ha$^{-1}$ near the tree line (0–3 m) as compared to their respective controls, in three- and four-year-old plantation, respectively. Potassium also responded in similar manner. Likewise concentration of nutrients was also influenced at different distances. These results are corroborated with those of Dhillon [16] and Gill et al. [5] who reported that nutrients uptake by wheat crop was reduced near the eucalyptus tree line. Thus, the significant reduction in biomass production of wheat near the tree line (between 0 and 3 m distance) can be attributed to severe competition for moisture and nutrients between trees and wheat.

Contrarily, synergetic effect was obtained between 3 and 9 m distance during three-year and 6–9 m during four-year plantation. Synergetic effect between 3 and 9 m distance can be attributed to the microsite enrichment caused by favourable environment for wheat growth due to modification in microclimate at tree and crop interface. According to Douglas et al. [2] and Ding and Su [15], growing conditions are improved under shelter due to higher soil moisture, humidity, and night time carbon dioxide levels as well as lower evaporation and night time air temperatures. Rosenberg [17] identified reduced night time temperature as the most important of these factors as it reduced respiration. He further stated that rate of photosynthesis increased in the sheltered zone due to lower resistance of stomata which increased carbon dioxide diffusion rate. Thus, increase in total biomass production and nutrient uptake by the wheat crop can be ascribed by the already concluded facts.

## 5. Conclusion

Inferences can be drawn for the present study that wheat crop near the tree line suffered in terms of dry matter accumulation and nutrients uptake which though were present in abundance but could not be utilized by the crop

because of limited root system and their reduced availability. These negative effects can be minimized by growing wheat between 3 and 9 m distances of poplar trees because of the microsite enrichment caused by favourable environment for wheat growth due to modification in microclimate at tree and crop interface.

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