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COMPARATIVE GROWTH, YIELD AND YIELD ATTRIBUTES OF WHEAT UNDER POPLAR AND *EUCALYPTUS* BASED AGROFORESTRY SYSTEM

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Abstract

The present investigations entitled "comparative performance of promising wheat varieties under Poplar and *Eucalyptus* based Agroforestry systems". To study the comparative performance of wheat varieties (UP-2526, UP-2565, UP-2628, and DPW-621-50) under poplar and *Eucalyptus* based agroforestry system. Experiment was laid out in Split plot design with three main plots (open farming, poplar and *Eucalyptus* agroforestry system) and four sub plots (different wheat varieties). The observations on growth and yield parameters of wheat crop were recorded during rabi season. Germination count, plant height, number of tillers and dry matter accumulation were higher under open farming system than agroforestry system (poplar and *Eucalyptus).* Among wheat varieties UP-2526 showed higher germination count and maximum height, number of tillers and dry matter accumulation. Yield attributes like grain yield was higher in open farming (3.55t ha^{-1}) system as compared to agroforestry system. Among wheat varieties grain yield was significantly higher in UP-2628 (3.13t ha^{-1}).

Key words: Comparative growth, yield attributes and agroforestry system**.**

Introduction

Agroforestry is a land management system that combines trees and shrubs into farming landscapes to increase the farm productivity and sustainability of farming systems (Fikreyesus *et al*., 2011). Agroforestry is a tool to modify the microclimate under field conditions. The micro-environment under tree canopy enhances biological activity and accelerates the crop performance through yield attributes and yield (Chauhan *et al*., 2012). Poplar (*Populus deltoides* M.) based agroforestry system is one of the viable alternate land use systems to maintain/improve soil quality and obtain biological production on sustainable basis in the irrigated agroecosystem. Poplar (*Populus deltoides* M.) and Eucalyptus based agroforestry system is one of the viable alternate land use systems to maintain/improve soil quality and obtain biological production on sustainable basis in the irrigated agroecosystem.

Poplar and Eucalyptus and other fast growing species are intercropped with wheat (*Triticum aestivum* L.) during *rabi* season (November-April). These systems are widely practised in northen states of India *viz*., Panjab, Uttrakhand, Haryana, Bihar, Uttar pradesh and parts of central and eastern states such as Chhattisgarh, Madhya Pradesh and West Bengal (Sarvade *et al*., 2014)**.** The farmer grow poplar because of its short rotation period, ease of regeneration (coppice), leaflessness during winters, soil enriching, easy availability of quality planting material, good economic return with easy marketing and its compatibility with different agricultural crops.

Eucalyptus is an important tree species tolerant to salinity, thus has great potential for rehabilitation of salt-affected wastelands (Rawat and Banerjee, 1998). Poplar and Eucalyptus popularity01236 with the farmers is mainly due to its fast growth, high price, less competition with associated crops and pruning tolerant nature. A large quantity of litter fall is added through tree species which upon its decomposition affects the growth and yield of wheat crop. Keeping the above view the experiment was carried out to observe the effect of polar and Eucalyptus on wheat crop to generate data for agroforestry economics.

Germination count

Germination is the process by which an organism grows from a seed or similar structure. The most common example of germination is the sprouting of a seedling from seed of an angiosperm or gymnosperm. It is the process of reactivation of metabolic machinery of the seed resulting in the emergence of radical and plumule. Seed germination is a crucial process influences both crop yield and quality. Wassinck *et al*. (1954) observed that more light intensity increased the photosynthetic efficiency of crops resulting better growth under sole cropping as compared to agroforestry system. Olsen (1971) found that the presence of catechol and benzoic acid inhibitors in Poplar leaves, which inhibits the germination and growth of wheat varieties. Chellamuthu *et al*. (1977) observed that *Prosopis juliflora* reduced the germination percentage of gram and sorghum**.** Sundaramoorthy *et al*. (1995) reported that *Prosopis juliflora* significantly inhibited the seed germination in pearl millet. Singh *et al.* (1998) reported that fallen leaves of poplar interferes the emergence and/or seedling growth of wheat. This is the reason for poor wheat performance near the *Populus deltoides* shelterbelt.

Nandal and Dhillon (2005) reported that aqueous leaf extract of poplar adversely affected the germination of several wheat varieties WH-896, WH- 2687, WH-147 wheat varieties were unaffected at all concentrations. Khan *et al.* (2008) found that aqueous extract of *Eucalyptus camaldulensis* inhibit the germination of wheat as compared to control treatment.

Siddiqui *et al.* (2009) reported that aqueous leaf extract of *Prosopis juliflora* inhibited the seed germination and reduced radicle length of wheat. While the percentage seed germination decreased with increasing concentration of aqueous leaf extract of *Prosopsis juliflora.* Fikreyesus *et al*. (2011) studied that effect of *Eucalyptus camaldulensis* on tomato crop. The results showed that the inhibitory effect was more pronounced in radicle length and germination efficiency. Sarvade *et al*. (2014) reported that under Poplar plantation with decreasing tree spacing and fertility levels, growth of the crop significantly decreased. The interaction effect due to fertility levels and tree spacing was non-significant for crop growth parameters. In agroforestry system the main cause of growth rate reduction is competition between crop and tree species for natural resources.

Plant height

Plant height is one of the important factors which affect the leaf area display, its distribution and lodging resistance. Lodging reduces the cross sectional area of vascular bundles which in turn, disturbs the movement of photosynthetic assimilates and absorbed nutrients. In addition to this, there is a close association between plant height and harvest index of the crop. Shanker *et al.* (2005) observed that plant height significantly higher in sole crop and no significant difference was observed under different densities of *Hardwikia binata*. Tripathi *et al.* (2006) found that growth parameters of wheat were influence under shisam and *Salix* based agroforestry system. Plant height was more under sole crop than the wheat grown under shisham and *Salix.* Chauhan *et al*. (2011) found that plant height of wheat crop was decreased with advancement of the age of the poplar trees and the maximum plant height was recorded under control plots. The plant height in open was significantly higher than under block Poplar plantations. On an average, 10.7 to 23.3 per cent decrease in plant height was observed under plantations of different ages as compared to the wheat crop in open. Kumar *et al.* (2013) found that less height of wheat under *Eucalyptus* plantation due to reduced light intensity under *Eucalyptus.* During the experiment data was recorded in the month of December has clearly indicate that PAR available to crops under *Eucalyptus* was 40.42, 46.32 and 54.25 % at 9:30AM, 11:30 AM and 4:30 PM, respectively of light available to crops in open. Rao *et al*. (2016) conducted a field experiment to find out the growth and yield of wheat and paddy under four year old *Dalbergia sissoo* based agri - silviculture system on sodic soil in eastern Uttar Pradesh. Results revealed that plant height (89.33 cm and 98.00 cm) and straw yield (1.15 t ha^{-1} and 1.59 t ha^{-1}) of wheat HD-2643 and paddy Narendra Usar-2 were found better respectively, when the crop were grown at 1.0 m away from *D. sissoo* tree base in the alley cropping.

Dry matter accumulation

The dry matter or dry weight is a measurement of the mass of something when completely dried. The dry matter of plant consists of all its constituents excluding water. Grain yield has usually been positively correlated with total dry matter production and nutrient accumulation in crops Rhoads and Stanley (1981). Meanwhile, DM accumulation varies with growth stage of crops Fageria and Baligar, (2005). Many previous studies indicated that DM and N accumulation for wheat occurred mainly pre-anthesis, and that grain yields greatly depended on the translocation of pre-anthesis assimilates and N accumulation Cox *et al.* (1985). Tomar *et al.* (1997) observed that dry matter accumulation of wheat, lentil and chick pea is higher in sole crop than under intercrops. Sharma *et al*. (2000) reported that under poplar, wheat growth at 30 days after sowing showed that dry weight of shoot per plant increased significantly between 3-12 and 3-15m distance from the tree line of 3 and 4 year old trees, respectively, over controls. Similarly dry weight of root per plant reduced significantly over the respective controls.

Sharma and Dadhwal (2007) found that dry matter accumulation and leaf area index increased significantly between 3-9m distances from tree line, depending upon the age of poplar plantation. Jilariya (2016) studied the *Aloe vera* intercropped under *Melia composita* Wild. based silvi-medicinal system (*M. composita* (2×2 m, 3×2 m, 4×2m)-*Aloe vera*) and sole cropping system. Results revealed that fresh and dry biomass (above ground, total, mature leaf, gel, leaf peel and aloin) were significantly higher under (2×2 m)-aloe silvi- medicinal system. However, non significant effect on below ground fresh biomass was observed. The fresh and dry biomass was decreased with increased spacing of *M. composita* and minimum under sole *Aloe* crop.

Number of effective tillers

A wheat plant grows numerous tillers of which many reach full maturity. However, when grown at high population densities, the same wheat plant can produce as few as1 tiller or even no tillers at all. The number of leaves determines the size of the crop canopy and its photosynthetic potential. The number of tillers and how many of these survive through to harvest also determines the number of ears at harvest and so the potential yield. Both of these factors depend on adequate crop nutrition and fertilisation. Bijalwan and Dobriyal (2014) studied different varieties of wheat under *Grewia optiva* traditional agroforestry system. Results revealed that number of effective tillers was higher in control than agroforestry system. Kohali *et al*. (1997) reported that lesser number of tillers under poplar agroforestry system due to shading effect. Khan *et al.* (2013); and Kumar *et al.,* (2013) also observed lesser number of tillers under agroforestry system than sole cropping.

Yield and Yield attributes

The wheat spike contains a variable number of around 24 to 28 spikelets, each with several florets. Grains can differ in terms of developmental stage, weight, number and fruiting efficiency when compared among different spikelets and even within individual spikelets Li *et al*. (2012). The middle spikelets have more and heavier grains than the basal and top spikelets Boz *et al.* (2012). Spikelet numbers, grain weight and grain numbers per spikelet have also a significant effect on thousand grain weight (TGW) and grain number per spike. The degree and rate of filling of the grains in individual spikelets varies highly by their position at the spike Yang *et al.* (2006).

Spike length

Gill *et al*. (2009) reported while studying the Productivity and nutrient uptake of newly released wheat varieties at different sowing times under poplar plantation that the spike length of wheat was decreased with increased age of poplar. Maximum spike length was observed in PBW 502 and PBW 373, respectively. Kumar *et al*. (2013) conducted a field experiment on wheat and mustard under *Eucalyptus* plantations. Results showed that spike length was significantly less under *Eucalyptus* than sole cropping. Sarvade *et al.* (2014) observed that ear bearing shoots were highest under poplar and followed by *Melia, Leucenea* and

Eucalyptus plantation. Under poplar spike length was significantly higher at wider spacing with 180 kg ha^{-1} nitrogen, 60 kg ha^{-1} phosphorus, 40 kg ha^{-1} fertility levels. The spikelets $spike^{-1}$ was followed the same pattern of spike length. Poplar (43.7) interface at wider spacing (42.8) with 180-60-40 kg NPK ha^{-1} fertility levels (51.2) recorded significantly higher grain numbers $spike^{-1}$.

Number of spike per plant

Razzaque and Rafiquzzaman (2006) reported that number of tillers was reduced when wheat was sown in 20th, December which was exposed to higher temperature and longer day length at the time of tillering and grain filling period**.** Kumar *et al*. (2013) reported that lesser number of siliqua per plant in agroforestry system than the open farming system due to competition for moisture, light, nutrients and allelopathic effect of *Eucalyptus.* Banga *et al.* (2017) found that number of spike under poplar clones was significantly affected by different varieties.

Number of grain per spike

Kumar *et al*. (2013) also reported that grain per spike of wheat is less under *Eucalyptus* than sole cropping. In mustard siliqua per plant and no of seeds per siliqua is higher under sole cropping. Gawali *et al.* (2015) reported that higher number of grain per spike was found in sole wheat crop than intercrop. Daniel and Larkin (2017) also reported that grain per spike was more in control than agroforestry system.

Test weight

Sharma and Dadhwal (2007) observed that 1000 grain weight of wheat increased significantly between 3-9m distances from tree line, under boundary plantation of poplar. Gill *et al.* (2009) reported that under poplar plantation 1000 grain weight of wheat varieties was higher when sown early (mid November) under poplar irrespective of its age of plantation. Kumar *et al*. (2013) also found that under *Eucalyptus* based agroforestry system test weigh of wheat was less than the sole cropping. Sarvade *et al.* (2014) revealed that test weight of wheat was higher under poplar (36.4g) at wider spacing. Poplar with 3 × 2.5 m spacing recorded highest test weight (39.0 g). Rani *et al.* (2015) studied the performance of wheat and toria under poplar based agroforestry system. The study revealed that plant height, no. of grain per ear, seed and straw yield of wheat and toria was better in sole cropping than under poplar based agroforestry system.

Biological yield

Yadav *et al.* (1993) observed that plant density and biomass production of mustard crop under *Acacia nilotica* trees declined with increasing canopy spread towards the tree stem. Thevathasan and Gordon (1997) observed that above ground biomass of barley (grain + straw) was reduced with increased poplar age. Grain yield was about 35-40% of barley Barley yields in 1993 and 1994 were significantly ($P < 0.05$) higher when it was close to the poplar tree row when compared with the middle of the row crop yield. Kohali and Saini (2003) reported that the above ground biological yield of wheat was lower in all agroforestry treatments than in the control. Gill *et al.* (2009) observed that wheat varieties Sown at different time under poplar plantation showed highest grain yield and nutrient uptake of wheat was higher under sole crop than under trees. Wheat was sown during mid November showed highest grain yield. Rao *et al.* (2016) reported that wheat and paddy under *Dalbergia sissoo* showed that maximum number of per ear/panicle and 1000 grain test weight (grain yield 2.32 t ha^{-1} and 2.33 t ha^{-1}) of wheat NW-1067 and paddy Narendra Usar-2 were recorded respectively, when crop were grown in sole crop.

Grain yield

Puri and Bangarwa (1992) conducted an experiment to observe the effect of trees on wheat crop, and found that *Dalbergia sissoo* reduced the yield by 4 to 30% but the reduction was only up to a distance of 3m. The wheat yield was reduced to a maximum on the north side of the trees and had almost no effect in the southern direction. Ralhan *et al*. (1992) reported that under three years old poplar plantation wheat yield was reduced by 23.3%. Pruning of poplar after three year permitted some recovery in yield. Singh *et al*. (1998) conducted a study to assess the effect of *Populus deltoides* Shelterbelt on wheat. Grain yield of wheat at maturity were significantly lower, upto 12 ± 1 m in shelterbelt then unsheltered plots of *Populus deltoides.* Phytotoxins and Phenolics of trees interferes the yield of wheat crop. Sharma *et al*. (2000) reported that wheat grain yield was reduced significantly compared to sole cropping at 0-3 m from the tree line with 4 year old plantation. Ahmed *et al.* (2004) found that there was a significant difference in yield of wheat grain and straw in different spacing over three years. The significantly low yield of wheat grain and straw in 6×12 m spacing was probably due to increase in competition between agriculture crop and trees.

Sharma and Dadhwal (2007) found that no significant adverse effect on wheat grain yield when grown with association of 3 year old boundary plantations of poplar. Whereas, decline of yield was there i.e. up to 3 m from the tree base in a 4 year old plantation. Chauhan *et al*. (2009) found that wheat under different ages of poplar shows decreasing yield. The rate of decrease during third to fourth year is negligible and non-significant. The decrease grain yield was 11, 39, 50 and 54 per cent at one, two, three and four year age of plantation, respectively than the control. Gill *et al*. (2009) reported that wheat varieties sown in different times under poplar plantation showed reduction in wheat yield. The grain yield and nutrient uptake of wheat varieties was higher in open conditions than under the trees. The highest grain yield was recorded when crop was sown during mid November. Kaur *et al.* (2010) observed that wheat yield under Poplar was reduced than the sole crop and it increased with the increase in tree age. Pandey *et al*. (2011) conducted experiment to evaluate the productivity and growth of crop black gram (*Phaseolus mungo*) and *Azadirachta indica*. Yield of *Phaseolus mungo* was decreased 60%, 71% and 80% in 1997, 1998 and 1999, respectively under the tree. Tree canopy management of *Azadirachta indica* was required to enhance the crop yield. Chauhan *et al*. (2011) reported that grain yield of wheat was significantly lower under poplar and it also declined with advancement of age of poplar. Less growth and yield under poplar may be due to increased competition for different resources, microclimate and presence of leaf litter of poplar during wheat germination. Pandey *et al.* (2011) while studying the performance of gram (*Cicer arietinum*) under neem based agroforestry system observed the reduction in grain yield under tree canopy. Kumar *et al.* (2013) conducted a field experiment on wheat and mustard under *Eucalyptus teriticornis* and found that grain yield of both crops is decreased significantly as compared to sole cropping. The reduction (63.2%) was less in wheat. Sarvade *et al.* (2014) found that highest grain yield (36.0q ha^{-1}) was under open

farming system. The reduction in grain yield was 16-62% under agroforestry system as compared to sole crop. Tomar *et al.* (2014) revealed that early sown wheat varieties gave 12.8 per cent higher grain yield than late sowing wheat varieties. The late sown varieties grain yield was reduced by 38.19q/ha which was 19.3 per cent lower than early sown varieties. Verma and Rana *(*2014) investigated the performance of tree growth and crop yields of paddy and wheat under *Eucalyptus teriticornis*. The grain yield (1.49t ha) under tree was lower than that of open cultivation. Sarvade *et al.* (2014) conducted an experiment on wheat under Poplar and found that crop yield under poplar was decreased as compared to sole cropping. This could be fast growing nature of poplar. Wang *et al*. (2014) reported that wheat under jujube plantation showed reduction in grain yield by 12 and 11 % in 3-year-old jujube trees, by 24 and 23 % in 5-year-old jujube trees, and by 38 and 37 % in 7-year-old jujube trees compared with sole wheat crop. Rajalingam *et al.* (2016) studied performance five vegetable crops (tomato, brinjal, cluster bean and vegetable cow pea) under *Alianthus excelsa* based agroforestry system. Results showed that growth and yield of vegetable crops was reduced under intercropping as compared to sole cropping. Among these vegetable crops tomato was most affected and cluster beans was least affected.

Straw yield

Ramshe *et al.* (1995) also concluded that the straw yield of wheat was higher under sole cropping as compared to agroforestry system. Bijalwan *et al.* (2011) reported that straw yield of agriculture crops was 3587 kg/ha/year in sole agriculture crops. The straw yield is recorded to be 2213 kg/ha/year as compared to 3084 kg/ha/year in the control condition. Straw yield was low under agri-horti-silviculture system as compared to sole cropping. Chauhan *et al*. (2011) found that straw yield of wheat crop was higher in open than under poplar plantation**.** Straw yield was also decreased with increased age of poplar up to 6th year.

Chauhan *et al.* (2012) observed that straw yield was significantly decreased under poplar plantations and the reduction of 12.46% was under first year plantation and 48.72% under five year old plantations. Kumar *et al.* (2013) observed that growth parameters of wheat and mustard were affected under *Eucalyptus* based agroforestry system. Results revealed that parameters such as spike length (7.7cm), grain per spike (37.7) and test weight (26.7g) of wheat and mustard was less under *Eucalyptus* based agroforestry system as compared to sole cropping. Rani *et al*. (2015) found that growth parameters of wheat and toria were affected under poplar based agroforestry system as compared to sole cropping. Grain and straw yield of wheat and oil crop was higher under sole cropping than poplar based system.

Harvest index

Kumar and Rajput (2003) reported that wheat varieties UP 2338, WH 542, Raj 3077, PBW 154, HD 2285, HD 2329, UP 2113, UP 2003, PBW 226, UP 262 and PBW 343 differed in respect of yield contributing characters (spikes per meter row length, number of spikelet's per spike, number of grains per spike, grain weight per spike and 1000-grain weight) and yield. UP 2338, Raj 3077 and PBW 226 showed the greatest tolerance to sub-optimal growth conditions and produced maximum yield in both systems. They also reported reduction in grain and straw yield and harvest index compared to sole production. Pedersen and Lauer (2004) conducted a field experiment from 1997 to 2000 using 5 management systems. Management system influenced development of the different yield components and produced seed mass ranging from 10.5 to 16.5 g 100 seed^{-1}, seed number from 2878 to 3824 seeds m^{-2}, pod number from 1182 to 1571 pods m^{-2}, and seeds per pod from 2.36 to 2.49 seeds pod^{-1} Harvest index ranged from 56.2 to 58.0% across management systems. Harvest index of hardin was (60.1%) and spansoy 250 the lowest harvest index (54.5%).

Bijalwan (2012) Results revealed that harvest index varied from 16.42% (*Amaranthus caudatus*) to 45.01% (*Phaselolus vulgaris*) in summer season and 27.49 (*Brassica campestris*) to 47.15 (*Pisum sativum*) in winter season in northern aspect under agri-horticulture system.While the harvest index in the southern aspect varied from 26.44 (*zea mays*) to 47.05 (*Phaseolus vulgaris*) in summer and 24.94 (*Coriandrum sativum*) to 47.37 (*Pisum sativum*) winter season under agr-ihorticulture system. Gawali *et al.* (2015) observed that harvest index was reduced under closer spacing of poplar and highest straw yield under sole cropping.

Conclusion

All these findings reports that Grain, straw and biological yield of wheat was decreased significantly under poplar and *Eucalyptus* as compared to control. Light, moisture and nutrients are the most important limiting factors which influence the overall growth and yield of agroforestry systems. Wheat yield and yield contributing characters differed significantly in an open field (sole system) and under poplar and *Eucalyptus* trees. Significant yield reduction by tree species could be due to their shading effect and below ground competition for resources. The higher wheat yield under Poplar compared *Eucalyptus* based agroforestry system may be due to their leaf shedding habit before wheat sowing in winter season and tree-crop complementary effects for resource allocation. Wider tree spacing reduces the tree-crop competition and increases crop yield. Substantial yield advantages have been reported for Poplar-wheat system in India resulting from temporal separation of resource capture, especially light, because wheat is generally sown in autumn (November), following leaf fall in poplar, and reaches maturity prior to renewed flushing of the trees in the following spring. Result showed that fallen leaves near *Eucalyptus* tree might be one of the factors that adversely affect the growth of wheat crop in agroforestry.

Numerous previous reports describe positive and/ or negative impacts of tree canopies on the performance of associated crops. The study suggests that the plants grown in the absence of trees as sole crop had better opportunity for greater solar energy for photosynthetic activity. The absence of interspecific competition for critical resources like moisture, nutrients and photosynthetically active radiation seems to favour better growth of wheat in sole crop relative to agroforestry.

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