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Comparison of two land use systems and its effect on wheat growth, yield and soil nutrient status

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Abstract
Field experiment was conducted during *Rabi* 2013 at old Agroforestry Research Centre in GBPUA&T, Pantnagar to investigate the influence of poplar based agroforestry system on wheat growth and yield as well as on soil nutrient availability and compare them with open system (without poplar tree). Experiment was laid out in randomized block design with three replications having four treatments viz., UP-2572, PBW-550, DBW-711 and PBW-373. Availability of soil nutrients viz., nitrogen, phosphorus and potassium was measured at a depth of 0-15 and 15-30 cm depth from each plot having different wheat varieties. Under both land use system the availability of nutrients was not influenced significantly because of early tree plantation. Agroforestry require long duration to result high nutrient accumulation. Under open system, significant maximum plant height and dry biomass was found with UP-2572 while in poplar system found with PBW-373. All the yield attributing characters viz, spike length, number of spikelets, number of fertile spikelet, grain/spike and 1000 grain weight under both systems was found maximum with UP-2572 except 1000 grain weight under poplar system. Wheat yield also found maximum with UP-2572 under both the systems.

Keywords: Agroforestry, nutrient, variety and wheat

1. Introduction
The rising population pressure and urbanization, coupled with land degradation, and global warming are the major causes for unsustainability in food production in developing world. Among different approaches to combat this problem, agroforestry, or woody perennial based intercropping systems, has proved itself as a key component of sustainable agriculture and is popular in addressing the issues related to supply of wood, fuel and fodder and to preserve fragile agro-ecosystem. It not only arrests land degradation but also improve site productivity through interactions among trees, soil, crops and/or livestock, and thus restore part, if not all, of the degraded lands (Kumar, 2006) [13]. Agroforestry is considered as a panacea for maladies of intensive agriculture. It is a way out to practice agriculture without deteriorating agro-ecosystem. Its role in the light of combating hunger, diseases and environmental degradation is highly appreciable (Garrity, 2004) [8]. Agroforestry (growing trees + crops) provides a viable option to these systems with opportunities to diversify as well as increase overall land productivity and nutritional security. Poplar's attributes such as ease of propagation through cuttings, easy establishment, rapid growth, straight cylindrical bole, deciduous nature and high volume returns make this species suitable for cultivation under agroforestry systems (Chandra, 2011) [11]. Karnatak (1996) [12] emphasized that poplar can be grown on a short rotation of 5–7 years and the farmers need not to wait for long for realizing the returns and they can make use of inter-space of fruit plants judiciously for economic gains. Besides, poplar trees are characterized by higher rates of nutrient accumulation in soils through litter fall as compared to other deciduous tree species. Poplars are efficient in the cycling of nutrients and a large portion of nutrients utilized for annual growth are periodically involved in cycling. The leaf fall contribute to the addition of organic matter as well as nutrients to soil (Bernier, 1984) [2].

2. Material and Methods
Experimental site
The field experiment was conducted during winter season of 2012-13 at experimental site of Agroforestry Research Centre (old site) near Horticulture Research Centre, Patharchatta of G.B. Pant University of Agriculture and Technology, Pantnagar, Distt. Udham Singh Nagar,

Uttararakhand. The Centre at Pantnagar is located between 28^0 58'N to 29^0 1'N Latitude and 79^0 24'E to 79^0 31'E longitudes and at an altitude of 243.84 meters above the mean sea level, which lies in the foothills of the Shivalik range of the Himalayas in the nar**r**ow strip called '*Tarai.*

Climate and Weather

The climate and weather of Pantnagar is humid sub-tropical with cold winters and hot dry summers. The maximum daily temperature in summer may reach up to 42^0 C and minimum temperature in winter may fall up to 0.5^0 C. Monsoon sets in the second or third week of June and continues up to the end of September. Generally, south-west monsoon sets in the second or third week of June and continues up to the end of September. The mean annual rainfall is about 1450 mm, of which 80-90 per cent is received during the wet season (July and September).

Experimental Design, Treatments and Measurement

The experiment was laid out in randomized block design with three replications. Four treatments were made up with different wheat varieties viz., UP-2572, PBW-550, DBW-711 and PBW-373 under open and poplar based agroforestry systems. In poplar based agroforestry system, the clones of *Populus deltoides* viz., PH 7 and PH 8 were taken at 3.0×7.0 m^2 spacing during 2012. The diameter of poplar tree was measured at breast height of 1.37 m with meter tape and height was measured with bamboo stick of 8 m length. The volume is determined by using the following as given in Forest mensuration, Chaturvedi and Khanna, 1982 [4].

$V = (g/4)2 \times h$

Where, V = volume of tree over bark

g = girth at breast height

h= height of the tree

The wheat (*Triticum aestivum* L.) varieties were sown on October 26, 2013 at a spacing of 22.5 cm with recommended cultural practices. For evaluating the wheat growth, the growth parameters like plant height, root length and plant dry biomass were observed at 90 days after sowing (DAS) from each plot and from each replication. For evaluation of yield and yield attributing character, wheat plants were harvested from net plot of $3X1m^2$ dimensions. To determine the nutrient availability in soil, the soil samples were taken at the depth of 0-15 and 15-30 cm after harvesting from each plot and from each replication. Analysis of nutrients like nitrogen is done by kjeldahl method using alkaline potassium permanganate, potassium by flame photometer and phosphorus by Olsen's method (Jackson, 1967) [11].

Statistical Analysis

The data obtained for different soil parameters were statistically analyzed by two way general analysis of variance procedure, treating species and soil depth as two factors (Gomez and Gomez, 1984) [9]. Wherever the effects exhibited significance at 5 per cent level of probability, the critical difference (CD) was calculated. Analysis was carried out on computer using the package "STPR". Correlation studies **(**Panse and Sukhatme, 1978) [14] were also performed to study the inter-relationship between various parameters under present investigations.

3. Results and Discussion

Soil Nutrient Status

The availability of nitrogen, phosphorus and potassium was not significantly influenced under different wheat varieties at the depth of 0-15 and 15-30 cm under both land use system, poplar based agroforestry system as well as open system except nitrogen availability which was significantly influenced by all the wheat varieties under open system at 15-30 cm (Table 1). The highest nitrogen content was observed with DBW-711 which was comparable to PBW-373. However, the availability of nitrogen at 0-15 cm was found maximum with DBW-711 under open system and with UP-2572 under poplar system, whereas, at 15-30 cm it was found maximum with PBW-550. The availability of phosphorus was attained highest with UP-2572 under open system and DBW-711 under poplar system at 0-15 cm while at 15-30 cm under both the systems, it was found maximum with PBW-550. DBW- 711 showed maximum content of potassium at 0-15 cm under both the systems while at 15-30 cm, PBW-550 and UP-2572 recorded maximum amount of potassium under open and poplar system, respectively. The highest available soil N, P_2O_5 and K_2O were recorded under intercropping of wheat with poplar. Nutrients are made available to plants in agroforestry mainly by atmospheric nitrogen fixation and mineralization of nutrients from organic forms (Hymavathi *et al*., 2010) [10]. The intercropping of trees with crops that are able to biologically fix nitrogen is common in tropical agroforestry systems. Non N-fixing trees can also enhance soil physical, chemical and biological properties by adding significant amount of organic matter and releasingand recycling of nutrients in agroforestry systems (Antonio and Gama-Rodrigues, 2011) [1].

Table 1: Effect of open farming and poplar based agroforestry systems on available nutrients (kg/ha) in different profile depths.

Treatment	Soil Depths											
	0-15 cm						15-30 cm					
	Open			Poplar			Open			Poplar		
	N	P	K	N	P	K	N	P	K	N	P	K
UP-2572	249.39	21.14	207.57	253.48	22.34	219.63	210.55	15.35	179.88	212.5	18.32	191.64
PBW-550	250.47	19.91	207.03	252.29	21.88	219.44	210.52	15.54	180.03	213.31	18.69	189.97
DBW-711	250.53	20.41	208.19	253.11	22.72	220.13	212.41	15.38	179.49	212.36	18.07	191.02
PBW-373	250.06	20.32	207.29	252.97	22.46	219.57	211.24	15.53	179.84	212.14	18.28	191.63
SEm±	0.80	0.42	1.06	0.66	0.36	0.66	0.39	0.54	0.70	0.68	0.61	0.62
CD at 5 %	NS	NS	NS	NS	NS	NS	1.4	NS	NS	NS	NS	NS

Tree Growth

The data presented in (Table 2) for growth parameters (diameter, height and volume) of poplar tree show increasing trend at the rate of 43.86 per cent in diameter (2.38-4.24 cm), 33.8 per cent in the tree height (4.56-6.89 m) and 78.9 per cent in the volume of poplar clone PH-7 whereas clone PH-8 showed 43.1 percent increase in diameter (2.94-5.17 cm), 32.2 percent in tree height (5.11-7.54 m) and 90.32 per cent in the volume. The per day increase in growth of poplar clone PH 7 was at the rate of 0.049 cm in girth, 0.019 m in height and 0.005 m^3 in volume and for clone PH 8 it was 0.058 cm, 0.02 m and 0.009 m^3 per day increment in tree girth, height and volume, respectively during the experimental year 2013-14. Between both of the clones, the growth rate of clone PH 8 was slightly higher than the clone PH 7. Fig 1 and 2 showed that with increase in crop duration the growing rate of clones also increases.

Table 2: Growth parameter of poplar tree at different growing stages of wheat

Growing stages of wheat	Girth (cm)		Tree mean DBH (cm)		Tree mean height (m)		Volume (m^3)	
	PH-7	PH-8	PH-7	PH-8	PH-7	PH-8	PH-7	PH-8
At sowing	7.47	9.23	2.38	2.94	4.56	5.11	0.16	0.12
30 DAS	9.17	11.15	2.92	3.55	4.90	5.76	0.25	0.45
60 DAS	11.08	12.34	3.53	3.93	5.57	6.47	0.43	0.62
90 DAS	12.15	14.7	3.87	4.68	6.02	6.92	0.56	0.94
At harvest	13.31	16.23	4.24	5.17	6.89	7.54	0.76	1.24

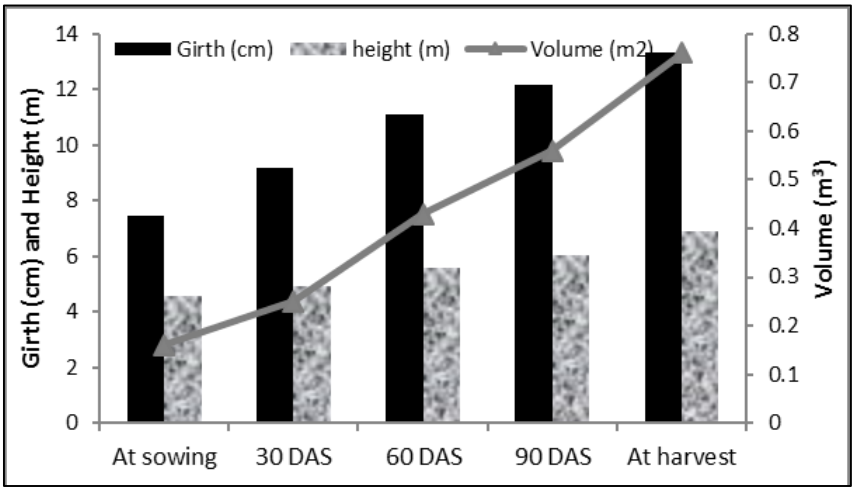

Fig 1: Effect of different growing stages of wheat on growth parameters of Poplar clone PH 7

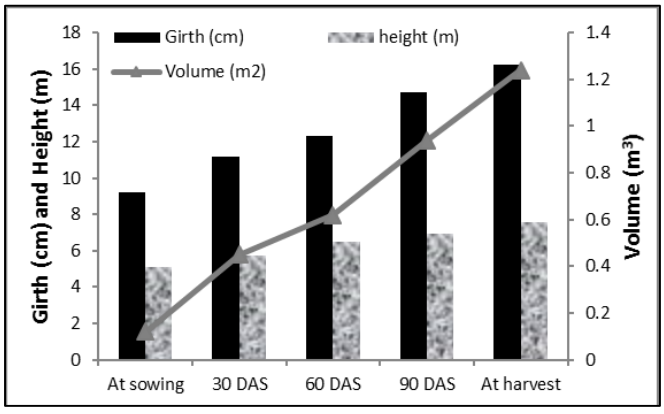

Fig 2: Effect of different growing stages of wheat on growth parameters of Poplar clone PH 8

Plant Growth

Growth parameters viz., plant height (cm) and dry biomass of plant (g) at 90 DAS was significantly influenced by the wheat varieties under both the systems while root length (cm) at 90 DAS was significantly influenced under open system only (Table 3). Wheat germination count done at 15 DAS was not significantly influenced by both the systems. However, maximum germination count recorded with PBW- 550 under both land use systems. At 90 DAS, the maximum plant height of wheat varieties under open system was attained with UP-2572 while under poplar system it was recorded with PBW-373 which was significantly superior to DBW-711 under both land use systems Open system recorded maximum total plant height as compare to poplar system. The same finding also reported by Patil *et al.* 2011 [15] and Chauhan *et al.* 2011 [6] when the effect of agroforestry was established**.** Under open system, longest root length at 90 DAS was achieved with PBW-373 which was significantly superior to all other wheat varieties. Total higher root length was obtained under open farming system as compared to agroforestry system. This finding is in support of earlier report of Djanaguiraman *et al.* (2002) [7]. Dry biomass of wheat plants at 90 DAS was found maximum with UP-2572 under open system which was significantly superior to all other wheat varieties while under poplar system it was recorded with PBW-373 which was found comparable with DBW-711. Dry matter accumulation increases with the age of the crop. In general above ground dry matter accumulation in plants was higher in open farming system as compared to agroforestry system Tripathi *et al*., 2006 [17] and Sharma *et al*., 2012 [16].

Table 3: Effect of open farming and poplar based agroforestry systems on germination Count (in one meter row) and growth parameters of wheat

Treatment	Germination Count (At 15 Days)		Plant Height (cm) at 90 DAS		Root Length (cm) at 90 DAS		Dry biomass of plant (g) at 90 DAS	
	Open	Poplar	Open	Poplar	Open	Poplar	Open	Poplar
UP-2572	49.3	47.3	83.5	83.9	13.2	11.7	52.1	28.9
PBW-550	50.3	47.7	82.5	81.2	13.9	13.8	47.3	34.1
DBW-711	48.3	46.0	74.2	70.7	12.2	13.5	40.0	40.8
PBW-373	49.0	44.7	82.3	85.3	15.8	14.9	37.8	42.9
SEm±	0.8	1.4	1.8	2.3	0.4	0.9	0.6	1.1
CD at 5%	NS	NS	6.1	7.9	1.3	NS	1.9	3.6

Yield Attributing Characters

Under both the systems, all yield attributing characters except number of fertile spikelets, number of grain/spike and 1000 grain weight under poplar system was not significantly influenced by all the wheat varieties (Table 4). All the yield attributing character was found maxium under open system as compared to poplar system The longest spike length was achieved with UP-2572 (11.3 and 11.5 cm) under open and poplar system, respectively which was significantly superior to rest of the wheat varieties. Under open system, maximum number of spikelets (19.7) was found with UP- 2572 which was comparable with PBW-550 while under poplar system the same (19.3) was recorded with UP-2572 which was significantly superior to rest of the varieties. Maximum number of fertile spikelets (17.3) under open system was attained with UP- 2572 which was comparable with PBW-550. The wheat variety, UP-2572 recorded maximum number of grains/spike (51.7) and 1000 grain weight (58.9 g) which was comparable with PBW-550 and DBW-711, respectively. Tripathi *et al.* (2006) [17] reported that higher 1000 grain weight in sole wheat as compared to wheat grown either with Shisham or Salix.

Table 4: Yield Attributing Characters of Wheat

Treatment	Spike Length (cm)		No. of spikelets		No. of fertile spikelets		No. of grains per spike		1000 grain weight (g)	
	Open	Closed	Open	Poplar	Open	Poplar	Open	Poplar	Open	Poplar
UP-2572	11.3	11.5	19.7	19.3	17.3	16	51.7	48.7	58.9	53.7
PBW-550	10.1	9.7	18.7	17.7	16.7	15.3	50.3	46.3	55.1	50.3
DBW-711	10	9.1	17.7	16.7	14.3	15	43.3	43.7	56.9	55.7
PBW-373	9.6	9.1	17	16	14	14.3	42.7	43.3	51.4	46.5
SEm±	0.3	0.3	0.3	0.5	0.4	0.6	1.0	1.6	1.0	3.4
CD at 5%	1.0	1.3	1.2	1.6	1.4	NS	3.6	NS	3.5	NS

Yield

All the wheat varieties had significant affect on grain and biological yield while straw yield was not significantly influenced by these varieties under both land use system (Table 5). The maxium grain yield 45.3 and 41.3 q/ha under open and poplar system was achieved with UP-2572 which was significantly superior to rest of the treatments. As compared to open farming system maximum grain yield reduction (8.99 %) was recorded with the variety PBW-373 and it was minimum with PBW-550 (5.26 %) (Fig: 3). Chauhan *et al.* (2012) [5] also revealed that growth and yield of wheat decreased significantly with the increase in poplar age. Maximum biological yield (122.3 q/ha) was obtained with UP-2572 which was comparable with PBW-550 under open system while under poplar system, the same was also attained UP-2572 that was significantly superior to rest of the treatments. Highest harvest index was achieved with UP-2572 under both land use system. UP-2572 under open system and PBW-550 under poplar system recorded highest grain: straw ratio followed by PBW-550 and UP-2572, respectively.

Table 5: Yield of Wheat

Treatment	Grain Yield (q/ha)		Straw Yield (q/ha)		Biological Yield (q/ha)		Harvest Index (%)		Grain: straw	
	Open	Poplar	Open	Poplar	Open	Poplar	Open	Poplar	Open	Poplar
UP-2572	45.3	41.3	77	68.3	122.3	109.7	35.8	37.9	0.59	0.60
PBW-550	38	36	73.7	52.3	110.3	88.3	34.2	41.1	0.53	0.69
DBW-711	31.3	28.7	67.7	50	99	78.7	31.0	36.5	0.46	0.57
PBW-373	26.7	24.3	65	50.7	91.7	75	29.6	32.5	0.41	0.48
SEm±	1.9	0.9	5.5	4.9	4.6	4.6	-	-	-	-
CD at 5%	6.4	3.2	NS	NS	15.8	15.7	-	-	-	-

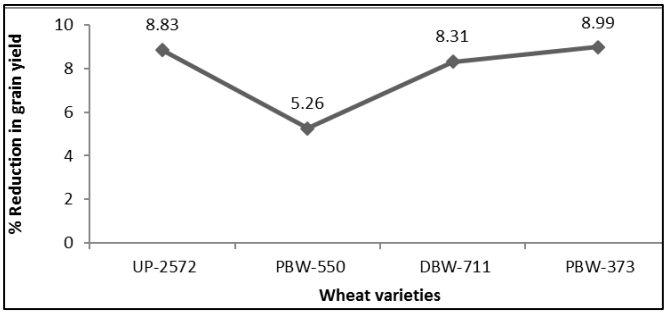

Fig 3: Per cent reduction in grain yield of wheat under poplar compared to open

Under open system, root length of wheat crop had negative significant correlation at high degree of level with spike length only. Dry matter accumulation showed high degree of positive correlation with number of spikelet, fertile spikelet, grain and straw yield and harvest index, while in poplar system they were not significantly correlated with any of the parameters of growth and yield of wheat crop. Spike length was not correlated with other parameters under open condition, whereas, in poplar system it was positively correlated at high degree of level with number of spikelets, grains/spike, straw and biological yield. Number of spikelet showed positive significant correlation with number of fertile spikelet, grains/spike, grain, straw and biological yield as well as harvest index under open system, whereas, in poplar system, the same was with number of fertile spikelet, grains/spike, grain and biological yield. High degree of significant correlation in number of fertile spikelet was observed with grains/spike, grain, straw and biological yield as well as harvest index under open system, while in poplar system it was found with grain yield only. Under open system grain/spike showed significant higher degree of correlation with all yield as well as harvest index, whereas under poplar system the same was reported with grain and biological yield. Grain yield under open system was significantly correlated at higher degree with straw and biological yield as well as harvest index while under poplar system it did not show any correlation. Straw yield had significant high degree of correlation with biological yield and harvest index under open system while in poplar system it has significant correlation at high degree with biological yield only. Biological yield had positive correlation at high degree with harvest index in open system only.

Table 6: Correlation coefficient among growth parameters, yield attributes and yield in open condition

Characters	Root length (cm)	Dry biomass (g)	Spike Length (cm)	No. of spikelets	No. of fertile spikelets	Grains/ spike	1000 grain weight (g)	Grain yield (q/ha)	Straw yield (q/ha	Biological yield (q/ha)	Harvest Index (%)
Plant Height(cm)	-.588	.487	.478	.547	.682	.695	-.018	.554	586	.562	.587
Root Length(cm)		-.889	-.987*	-.902	-.807	-.792	-.756	-.912	-.858	-.913	-.850
Dry biomass (g)			.926	.998**	.949*	.938	.842	.997**	.988*	.996**	.986*
Spike Length(cm)				.928	.814	.797	.849	.936	.882	.935	.874
No. of spikelets					.963*	.953*	.807	1.00**	.993**	1.00**	.991**
No. of fertile spikelets						.999**	.633	.959*	.986*	.961*	.988*
Grains/spike							.608	.950 *	.980 *	.952 *	.983 *
1000 grains weight (g)								.807	.751	.802	.745
Grain yield(q/ha)									.991**	1.00**	.989**
Straw yield(q/ha)										.992**	1.00**
Biological yield (q/ha)											.989**

Note: **Significant at 1% level of probability, *Significant at 5% level of probability

Table 7: Correlation coefficient among growth parameters, yield attributes and yield in poplar condition

Characters	Root length (cm)	Dry biomass (g)	Spike Length (cm)	No. of spikelets	No. of fertile spikelets	Grains/ spike	1000 grain weight (g)	Grain yield (q/ha)	Straw yield (q/ha	Biological yield (q/ha)	Harvest Index (%)
Plant Height(cm)	.826	.332	.635	.447	244	.546	-.510	.373	.657	.551	.134
Root Length(cm)		.633	.105	-.134	-.344	-.019	-.841	-.210	.163	-.010	-.558
Dry biomass (g)			.408	-.446	-.575	-.299	-.943	-.370	-.446	-.431	-.135
Spike length(cm)				.956 *	-.887	.953 *	.321	.893	.989**	.990**	.380
No. of spikelets					.976*	.987*	.454	.983*	.908	.988**	.626
No. of fertile spikelets						.937	.622	.973*	.832	.940	.701
Grains/spike							.313	.980*	.897	.980*	.631
1000 grains weight (g)								.439	.312	.389	.404
Grain yield(q/ha)									.820	.947	.756
Straw yield(q/ha)										.961*	.244
Biological yield (q/ha)											.504

Note: **Significant at 1% level of probability, * Significant at 5% level of probability

4. Conclusion

From the above investigation it can be stated that growth, yield and yield attributing characters of wheat was found maximum under open system as compared to poplar based agroforestry system. The availability of soil nutriens viz., nitrogen, phosphorus and potassium was not influenced significantly because of short duration of poplar tree. The poplar clone PH 8 showed higher rate of growth in respect to girth/diameter, height and volume. All yield attributing characters under both of the land use systems except 1000 grain weight under poplar system was recorded maximum with UP-2572. Grain yield of wheat under both the systems was also obtained maximum with UP-2572. The variety PBW 550 revealed lesser reduction percent i.e. 5.26% in poplar system as compared to open system, whereas higher reduction percent showed by PBW 373 (8.99%).

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