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Comparison of wheat yield and soil properties under open and poplar based agroforestry system

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Abstract: Field experiment was conducted during the *Rabi* season of 2013-14 on an established plantation at old site of Agroforestry Research Centre, Patharchatta of G.B. Pant University of Agriculture and Technology, Pantnagar, District Udham Singh Nagar, Uttarakhand, India to evaluate the effect of poplar based agroforestry system and open system (without poplar) on yield of different wheat varieties and soil physico-chemical properties.The experiment was laid out in randomized block design with 4 treatments and each replicated thrice under both the growing conditions. The crop treatments are wheat varieties viz. UP-2572, PBW-550, DBW-711 and PBW-373. The highest grain yield of all the wheat varieties was obtained under open farming system. Highest grain yield of wheat was recorded in UP-2572 (45.3 q/ha) under open farming system. Agroforestry is proven land use system for vertically enhancing soil health against unsuitable weather condition. The distribution of soil properties was detected from the depth 0-15 cm in poplar based agroforestry system and as well as in open system. During the experiment it was found that agroforestry add more nutrients to the soil compared to open system i.e. highest pH (7.9), EC (0.43 dSm^{-1}), available soil nitrogen (253.48 kg/ha), potassium (219.63 kg/ha) were achieved with UP-2572 while organic carbon (1.07%) and available soil phosphorus (22.72 kg/ha) were attained with DBW-711.

Keywords: Agroforestry, Correlation, Nutrient, Variety, Yield

INTRODUCTION

Agroforestry is considered as a panacea for maladies of intensive agriculture. It not only prevents land degradation but also improves site productivity through interaction among trees, soil and crops and thus restores soil fertility (Kumar, 2006). It is a way out to practice agriculture without deteriorating agro-ecosystem. Its role in the light of combating hunger, disease and environmental degradation is highly appreciable (Garrity, 2004). Wheat (*Triticum aestivum* L.) is widely intercropped cereal crop during *rabi* season (November-April) with Poplar, Eucalyptus and other fast growing tree species in northern states of India viz., Uttarakhand, Punjab, Haryana, Uttar Pradesh and Bihar, parts of central and eastern states such as Madhya Pradesh, Chhattisgarh and West Bengal. Poplar and Eucalyptus are the most successful industrial agroforestry tree species in India with extremely high productivity up to 10-30 m^3/ha/yr. Intercropping with high density short rotation tree species is the best option to meet increasing food and industrial raw material requirement through sustainable utilization of natural resources (Sarvade*et al.*2014). Cropping with tree species is an ancient practice and very important tool to achieve goal of National Forest Policy (1988). It has been reported as an important component of the 'evergreen revolution' movement in the country (Puri and Nair, 2004).Poplar trees are characterized by higher rates of nutrient accumulation in soil through litter fall as compared to open system. Poplars are efficient in the cycling of nutrients and a large portion of nutrients utilized for annual growth of arable crops. The leaf fall contribute to the addition of organic matter as well as nutrient to soil (Bernier, 1984). The investigation was mainly carried out to determine the impact of agroforestry system on soil properties and yield of wheat as compared to open farming system.

MATERIALS AND METHODS

A field experiment was carried out during *Rabi* season of 2013-14 at old site of Agroforestry Research Centre, Patharchatta of G. B. Pant University of Agriculture and Technology, Pantnagar, District Udham Singh Nagar, Uttarakhand, India. The experiment was laid out in randomized block design with two growing conditions open (without trees) and intercropping with poplar clone (PH7 and PH 8) and four varieties of wheat (UP-2572, PBW-550, DBW-711 and PBW-373) with three replications in each system. The clones of *Populus deltoids* viz., PH 7 and PH 8were taken at 3.0×7.0 m^2 spacing during 2012. The wheat (*Triticum aestivum* L.), varieties was raised with the recommended cultural practices during 2013. The effect of poplar

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clone and open condition on wheat crop was estimated in terms of yield (straw and grain). Grain and straw yield (q/ha) was determined on the net plot (3.0 m^2) area basis. Soil samples were collected after harvesting of the wheat crop from net plots at 0-15cm depth for the study of nutrient status and physico-chemical properties viz., available nitrogen (by kjeldahl method using alkaline potassium permanganate), potassium (by flame photometer) and phosphorus (by Olsen's method), organic carbon (Walkley and Black's method), pH and EC was determined by following standard procedures (Jackson, 1967). The data recorded for the above parameters of both the clones were averaged. For growth performance of tree, tree height and diameter at breast height (dbh) was measured at sowing time of wheat, 30, 60, 90 days after sowing of wheat crop and at harvest. The tree parameters for both the clones were recorded separately.

RESULTS AND DISCUSSION

Crop yield: Grain and straw yield of wheat was decreased under fast growing short rotation tree species (PH 7 and PH 8) as compared to open condition (Table 1). Maximum grain and straw yield was registered under the open condition. Grain yield was significantly affected by the different varieties of wheat under both open and closed condition, whereas straw yield were non- significant. The variety (UP-2572) recorded highest grain (45.3 and 41.3 q/ha) and straw (77.0 and 68.3 q/ha) yield in open and poplar based system, respectively which was closely followed by PBW-550,DBW-711 and PBW-373.

Light, moisture and nutrients are the most important limiting factors which influence the overall growth and yield of agroforestry systems. Significant yield reduction by tree species could be due to their shading effect and below ground competition for resources. Allelopathic effect is important cause of crop yield reduction in agroforestry systems (Prasad *et al*., 2010). The loss of yield, however, was not only due to the growth of trees but also due to the loss of land area to trees. There are other numerous reasons for reduction in yield under canopy. Whereas, the other half of yield reduction is due to the competition between the tree and crop for light, moisture, nutrients, etc. and the modification of micro environmental conditions. The reduced wheat grain yields in the agroforestry treatments relative to

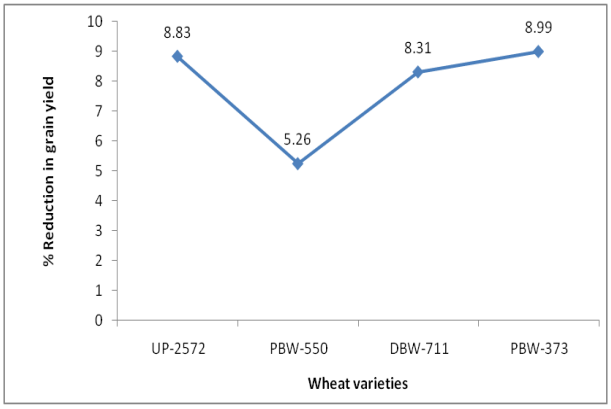

Fig. 1: *Per cent reduction in grain yield of wheat under poplar compared to open system.*

sole wheat demonstrate the existence of competition, as reported by Sarvade *et al.*(2014). Under poplar system, the minimum percent reduction in grain yield (5.26%) was achieved with PBW 550 while PBW 373 recorded maximum reduction percent (8.99%) as compared to open system (Fig. 1).

Soil physico-chemical properties: Soil *physico-chemical properties* (viz., pH, EC and organic carbon percent)were not significantly affected by different varieties of wheat as well as both the conditions (open and poplar plantation). The soil pH and EC was lowered under open condition compared to poplar interfaces. The greater pH in tree based land use system could be due to humic matters released as a result of tree root exudates that complex the aluminum (Al^{+3}) and consequently result in greater soil pH, especially in acidic soil while higher EC under poplar system may be due to production of organic acids from decomposition of litter and the effect of climatic variables viz. solar radiation, temperature, relative humidity, precipitation and wind velocity (Newaj *et al*., 2007). The highest pH and EC was recorded under the variety UP 2572 under poplar interface while the lowest was obtained with the same variety in open condition. Highest organic carbon was recorded from Poplar interfaces. High organic matter content in the intercropping treatment could be ascribed to the fact that leaf fall before and during crop sowing period on the soil which incorporates in to the soil through tillage practices and their partial decomposition adds to the soil organic matter. These results are similar with the results reported by Gupta and

Table 1. Effect of land use system on yield of wheat crop.

Treatment	Grain yield (q/ha)		Straw yield (q/ha)	
	Open	Poplar	Open	Poplar
UP-2572	45.3	41.3	77.0	68.3
PBW-550	38.0	36.0	73.7	52.3
DBW-711	31.3	28.7	67.7	50.0
PBW-373	26.7	24.3	65.0	50.7
SEm±	1.9	0.9	5.5	4.9
CD at 5%	6.4	3.2	NS	NS

Table 2. Correlation coefficient among soil parameters and yield in open condition.

Characters	Soil EC (dSm^{-1})	Soil organic carbon (%)	Available soil N (kg/ha)	Available soil P_2O_5 (kg/ha)	Available soil K_2O (kg/ha)	Grain yield (kg/ha)	Straw yield (kg/ha)
Soil pH	.354	.308	-.881	.111	-.656	.237	.263
Soil EC (dSm^{-1})		.302	-.175	-.883	-.826	-.141	-.010
Soil organic carbon (%)			.215	-.050	-.432	-.851	-.832
Available Soil N (kg/ha)				-.182	.409	-.706	-.718
Available Soil P_2O_5 (kg/ha)					.541	.142	.014
Available Soil K_2O (kg/ha)						.106	.009
Grain Yield (kg/ha)							.991**

Sharma 2009. The DBW 711 (1.07%) variety of wheat recorded higher organic carbon under poplar condition while in open condition it was with UP 2572 (0.97%). The variety PBW 550 recorded higher EC under both the conditions whereas lower electrical conductivity recorded with DBW 711(Fig. 2).

Soil nutrient status: Available soil N, K_2O and P_2O_5 were non-significantly influenced by both the condition open and intercropping of wheat with poplar (Fig: 3). 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). 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 releasing and recycling of nutrients in agroforestry systems (Antonio and Gama-Rodrigues, 2011). Different varieties of wheat with poplar showed non-significant effect on the soil available nutrients. Under intercropping system of wheat with poplar, wheat variety UP 2572 recorded highest available soil N (253.48 kg/ha) and K_2O (219.63kg/ha) whereasP_2O_5 (22.72 kg/ha) was maximum with DBW 711.

All soil parameters had non significant correlation coefficient with grain and straw yield either positive or negative. Grain yield had significant positive correlation coefficient at 1% level of probability with straw yield (Table 2).

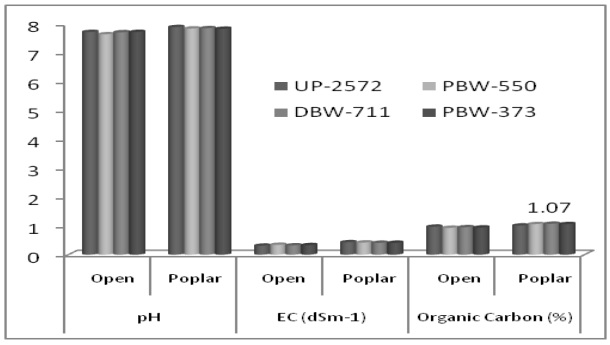

Fig. 2: *Effect of land use system on soil physico chemical properties.*

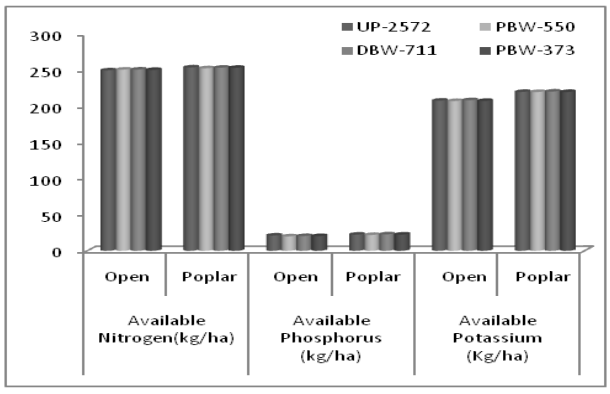

Fig. 3: *Effect of land use system on soil nutrient status.*

Conclusion

The data recorded indicate that intercropping of poplar with wheat crop is suitable for soil physico-chemical properties while sole crop was found suitable for grain yield of crop.Under poplar, highest pH (7.9), EC (0.43 dSm^{-1}), available soil nitrogen (253.48 kg/ha), potassium (219.63 kg/ha) were achieved with UP-2572 while organic carbon (1.07%) and available soil phosphorus (22.72 kg/ha) were attained with DBW-711. It was found that there was not a much difference in the production of grain yield of wheat when it was grown with poplar ranging from 24.3 to 41.3 q/ha as compared to open system varied from 26.7 to 45.3 q/ha under different wheat varieties.So, instead of sole crop we can adopt combination of arable crop and forest tree species (agroforestry) to enrich soil nutrients and to protect environment and forest trees.

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