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RESEARCH ARTICLE

EFFECT OF SOIL PROPERTIES ON WHEAT VARIETIES UNDER OPEN AND *EUCALYPTUS* BASED AGROFORESTRY SYSTEM

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ABSTRACT

Agroforestry Research Centre (old site) near Horticulture Research Centre, Patharchatta of Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, U.S. Nagar. To study the effect of wheat varieties on soil properties under open and *Eucalyptus* based agroforestry system. The experiment was laid out in Randomized Block Design with two growing conditions (open and *Eucalyptus* based system) and four varieties of wheat viz., WH-711, UP-2565, PBW-343, and PBW-17 with three replication in each condition. Soil pH varied significantly under both farming system at 0-15cm depth and non significant at 15-30cm depth. The higher soil pH was observed in plots under PBW-343 at a depth of 0-15cm and 15–30cm. Soil pH is observed higher under *Eucalyptus* based agroforestry system as compared to open farming system. Soil EC varied non significantly under both farming system at 0-15cm depth and significant at 15–30cm depth. The higher soil EC was observed in plots under PBW- 343 variety. Soil EC is observed higher under *Eucalyptus* based agroforestry system as compared to open farming system. Soil organic carbon (%) varied non significantly under both farming system. The higher soil organic carbon was observed in plots under PBW-343 variety. Soil organic carbon is observed higher under *Eucalyptus* based agroforestry system as compared to open farming system. Available soil nitrogen was not influenced significantly under both farming system. Maximum soil nitrogen was observed in plots under WH-711 variety. Available soil nitrogen is observed higher under *Eucalyptus* based agroforestry system as compared to open farming system. Available soil phosphorus was not influenced significantly under both farming system. Maximum soil phosphorus was observed in plots under PBW-343 variety. Available soil phosphorus is observed higher under *Eucalyptus* based agroforestry system as compared to open farming system. Available soil potassium was influenced not significantly under both farming system. Maximum soil potassium was observed in plots under PBW-343 variety. Available soil potassium is observed higher under *Eucalyptus* based agroforestry system as compared to open farming system.

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INTRODUCTION

Agroforestry or woody perennial based intercropping system, 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 to preserve fragile agro-ecosystem. It not only arrest land degradation but also improves site productivity through interaction among trees, soil, crops and/or livestock, and thus restore part, if not all of the degraded lands (Kumar, 2006).*Eucalyptus* belongs to the family Myrtaceae, mostly found in tropical region is a native to Australia. *Eucalyptus* spp. grow under a wide range of climatic and edaphic conditions in their natural habitats (Dawar*et al.*, 2007). Poplar and Eucalyptus are the most successful industrial agroforestry tree species in India with extremely high productivity up to 10-30 $m^3ha^{-1}yr^{-1}$. 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). The tree species behave differently at different planting densities. Spacing and planting layout of the tree species influence growth and yield of annual crops. Appropriate selection of tree and crop species helps to increase yield, improve soil fertility, promote land sustainability and resource use efficiency (Sharma *et al.*, 2004; Muthuri*et al.*, 2005; Jose, 2009; Dhyani*et al.*, 2009; Jha*et al.*, 2010; Antonio and Gama- Rodrigues, 2011). The wheat production technology under sole cropping system is well established but it may need some modification for mixed land-use system, like agroforestry particularly nutrient management aspect, where wheat is grown in association with trees. Agroforestry system has more than two components which makes it complex in nature. The fundamental challenge is therefore to develop a farming system that will be adopted and maintained by farmers. The dynamic nature of nutrient cycling is one of the obstacles in nutrient management in agroforestry systems.

It dictates that soil nutrient capital useful for supplying nutrients for plant growth must be equated with short to medium-term, rolling capital (the monthly or annual salary), rather than long-term reserves (gold in the bank). The role of organics is varied and complex, the challenge is to use organics of differing quality in combination with inorganic fertilizers to optimize nutrient availability to plants. A systematic framework for investigating the use of inorganic nutrient sources includes assessment of the fertilizer equivalency value and experimental designs for determining optimal use of nutrient sources. The desired outcome is tools that can be used by researchers, and farmers for assessing options of using scarce resource for maintaining soil fertility and improving crop yields. It is necessary to have quantitative information on how fertilization of stands under agroforestry system affects growth (both trees and crop), litter and nutrient return to the soil.

MATERIALS AND METHODS

The field experiment will be conducted during winter season of 2014-15 at Agroforestry Research Centre, Pattharchatta, of G.B. Pant University of Agriculture and Technology, Pantnagar, Distt. Udham Singh Nagar, Uttararakhand. The Centre is situated at 29^0 N Latitude, 79^0 30’ E longitude 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 narrow strip called ‘*tarai’* In the experiment there were two conditions, open and *Eucalyptus* based agroforestry system having 4 treatments of wheat along with Eucalyptus as an intercrop. The field data of *Eucalyptus* andwheat on sowing, 30DAS, 60DAS, 90DAS and Harvesting of wheat was taken and analysed. The data recorded from the study were subjected to analysis of variance technique using RBD for field experiment. Wherever the effects exhibited significance at 5per cent level of probability, the critical difference (CD) was calculated. Study the evaluation of different Soil parameters under Eucalyptus based agroforestry system with four treatments (wheat varieties) i.e.; T1: WH - 711 (Early sown) T2: UP -2565 (Late sown), T3: PBW -343 (Medium sown) and T4: PBW -17 (Late sown) were tested in randomized block design with three replications (under Eucalyptus plantation and in open field) with spacing 7m × 2m, date of wheat sowing 17. 11. 2014.

RESULTS AND DISCUSSION

Soil properties *viz.* Soil pH, electrical conductivity (EC), organic carbon (OC), available nitrogen (N), phosphorus (P) and potassium (K) are the important soil fertility parameters which affect the growth and yield of intercrops and overall production. The soils were evaluated for these parameters and result and discussion are presented.

Soil Ph: The effect of both the conditions on the soil pH showed in Table 1 At 0-15 cm soil depth, the soil pH was observed as 7.8 and 7.7 under open and *Eucalyptus* based agroforestry system and the difference was significant under open farming as compared to *Eucalyptus* based agroforestry system. The soil pH among different varieties of wheat varied from 7.5 to 7.9 but the difference was non-significant among different varieties in both soil depths.

Table 1. Effect of open farming and *Eucalyptus* based agroforestry systems on soil pH and their interaction at different profile depths 0-15 and 15-30 cm

Treatments	Ph		Mean
	Soil Depth (cm)		
	0-15	15-30	
Main plot (Farming system)			
C_1 (Control without tree)	7.8	7.7	7.7
C_2 (Agroforestry system)	7.7	7.6	7.6
SEm±	0.1	0 .1	
CD at 5%	**0.4**	**NS**	
Sub- Plot (Wheat Varieties)			
WH-711	7.9	7.7	7.8
UP-2565	7.5	7.5	7.5
PBW-343	7.8	7.9	7.8
PBW-17	7.7	7.8	7.7
SEm±	0.2	0.1	
CD at 5%	**0.6**	**0.5**	
CV	7.2	5.5	
Interaction	**NS**	**NS**	

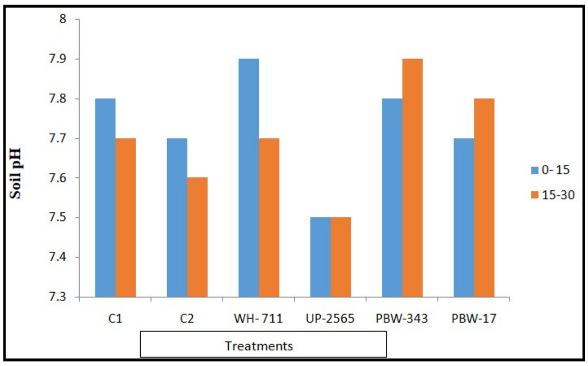

Fig. 1. Effect of open farming and *Eucalyptus* based agroforestry systems on soil pH and their interaction at different profile depths 0-15 and 15-30 cm

At soil profile depth of 15-30 cm, the soil pH was 7.7 under open farming system and it was 7.6 under *Eucalyptus* based agroforestry systems and the difference was not significant. In case of wheat varieties, the pH difference ranged from 7.5 to 7.9 but the difference was not significant. The interaction effect between open farming and *Eucalyptus* based agroforesty systems at different soil profile depths had no significant effect on soil pH.

Soil EC: The data presented in Table 2, Fig 2 on soil EC showed variation under open farming and *Eucalyptus* based agroforestry systems. It was 0.41 dSm-1 in control treatment and 0.43dSm-1 under *Eucalyptus* based system. The EC at soil depth, 0-15 cm was not significantly different with each other. The EC at a soil depth of 0-15 cm ranged from 0.40 dSm-1 to 0.44 dSm-1 in different varieties of wheat.

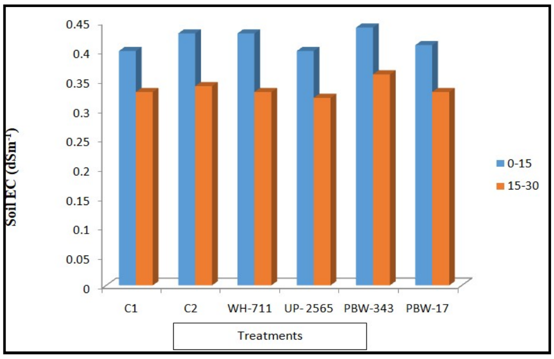

Fig 2. Effect of open farming and *Eucalyptus* based agroforestry systems on soil EC (dSm^{-1}) and their interaction profile depths 0 – 15 and 15 – 30 cm

Table 2. Effect of open farming and *Eucalyptus* based agroforestry systems on soil EC (dSm^{-1}) and their interaction profile depths 0-15 and 15-30 cm

Treatment	EC (dSm^{-1}) Soil Depth (cm)		Mean
	0-15	**15-30**	
Main plot (Farming system)			
C_1 (Control without tree)	0.40	0.33	0.36
C_2 (Agroforestry system)	0.44	0.34	0.39
SEm±	0.10	0.10	
CD at 5%	**NS**	**0.3**	
Sub plot (Wheat Varieties)			
WH-711	0.43	0.33	0.38
UP-2565	0.40	0.32	0.36
PBW-343	0.44	0.36	0.40
PBW-17	0.41	0.33	0.36
SEm±	0.10	0.10	
CD at 5%	**0 .3**	**NS**	
CV	9.00	11.80	
Interaction	**NS**	**NS**	

The highest EC of the soil was 0.44 dSm-1 in UP-2565 of wheat which differed non significantly at 5% level with EC of UP-2565, PBW-343 and PBW-17. The soil EC at depth15-30 cm was not significantly different with each other. The EC at a soil depth 15-30 cm ranged from 0.32 dSm-1 to 0.36 dSm-1 in different varieties of wheat. The highest EC of the soil was 0.36 dSm-1 in PBW-343 of wheat which differed non significantly at 5% level with EC of UP-2565, WH-711 and PBW-17. The interaction between open farming and *Eucalyptus* based agroforestry systems, at different soil profile depths no significant effect on electrical conductivities of soil was observed. The decrease in soil EC may be attributed to the production of organic acids form litter decomposition under joint effect of climatic variables (solar radiation, temperature, relative humidity, precipitation and wind velocity), consequently leaching of substances took place from upper horizon to lower horizon (Malik *et al.*, 1996; Imayavarambanet *al.*, 2001).

Soil organic carbon: The data presented in Table 3, Fig 3 on soil OC showed variation under open farming and *Eucalyptus* based agroforestry systems. The OC at soil depth, 0-15 cm was not significantly different with each other. The OC at a soil depth 0-15 cm ranged from 2.0% to 2.7% in different varieties of wheat. The highest OC of the soil was recorded in PBW-343 and PBW-17 varieties of wheat which differed non significantly at 5% level with OC of UP-2565 and WH-711. The soil OC at depth15-30 cm was not significantly different with each other. The OC at a soil depth of 15-30 cm ranged from 1.8% to 2.0% in different varieties of wheat. The highest OC of the soil was 2.0 in PBW-343 of wheat which differed non significantly at 5% level with OC of UP-2565, WH-711 and PBW-17.

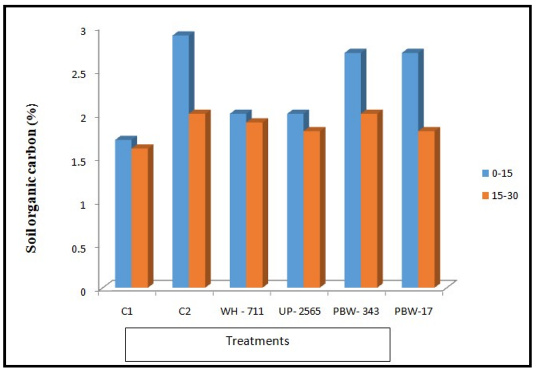

Fig 3. Effect of open farming and *Eucalyptus* based agroforestry systems on soil organic carbon (%) and their interaction at different profile 0- 15 and 15 – 30 cm.

Table 3. Effect of open farming and *Eucalyptus* based agroforestry systems on soil organic carbon (%) and their interaction at different at different profile 0- 15 and 15 – 30 cm

Treatments	Soil Depths (cm)		
	0-15	**15-30**	**Mean**
Main plot (Farming system)			
C_1 (Control without tree)	1.7	1.8	1.65
C_2 (Agroforestry system)	2.9	2.0	2.45
SEm±	0.4	0.1	
CD at 5%	**NS**	**NS**	
Sub- plot (Wheat Varieties)			
WH-711	2.0	1.9	1.9
UP-2565	2.0	1.8	1.9
PBW-343	2.7	2.0	2.3
PBW-17	2.7	1.8	2.2
SEm±	0 .6	0.1	
CD at 5%	**0.2**	**NS**	
CV	6.9	18.5	
Interaction	**NS**	**NS**	

The interaction between open farming and *Eucalyptus* based agroforestry systems, at different soil profile depths showed no significant effect on organic soil carbon of soil. In general, the trees have lignified cells in its body parts like litter, bark, small branches and roots and these lead to biochemical stabilization of organic carbon in the soil. Consequently, it led to improve soil organic carbon status under agroforestry system as compared to open farming system (control). Similar findings were also reported by Gupta *et al.*, 2009; Baum *et al.*, 2013.

Available soil Nitrogen: The data presented in Table 4, Fig 4 on soil available nitrogen showed variation under open farming and *Eucalyptus* based agroforestry systems. The soil nitrogen was 244.9 kg ha^{-1} at soil depth, 0-15 cm was not significantly different with each other. The soil nitrogen at a soil depth 0-15 cm ranged from 227.6 to 231.8 kg ha^{-1} in different varieties of wheat. The highest nitrogen of the soil was recorded in WH-711 varietyof wheat which differed non significantly at 5% level with available soil nitrogen of UP-2565, PBW-17 and PBW-343. The soil nitrogen at depth 15-30 cm was not significantly different with each other. The available nitrogen at soil depth 15-30 cm ranged from 223.4 to 225.1 Kg ha^{-1} in different varieties of wheat. The highest available Nitrogen of the soil was 225.1 kg ha^{-1} in PBW-343 of wheat which differed non significantly at 5% level with available nitrogen of UP-2565, PBW-343 and WH-711.

Table 4. Effect of open farming and Eucalyptus based agroforestry systems on available soil nitrogen, N (kg ha-1) and their interaction at different profile depths 0 – 15 and 15 – 30 cm.

Treatments	Availablesoil Nitrogen N (kg ha^{-1}) Soil Depths (cm)		
	0-15	**15-30**	**Mean**
Main plot (Farming system)			
C_1 (Control without tree)	213.9	211.4	212.6
C_2 (Agroforestry system)	244.9	237.0	240.9
SEm±	2.9	3.2	
CD at 5%	**NS**	**NS**	
Sub- plot (wheat Varieties)			
WH-711	231.8	224.8	228.3
UP-2565	227.6	223.4	225.5
PBW-343	229.5	225.1	227.3
PBW-17	228.7	223.6	226.1
SEm±	4.1	4.5	
CD at 5%	**NS**	**NS**	
CV	4.4	4.9	
Interaction	**NS**	**NS**	

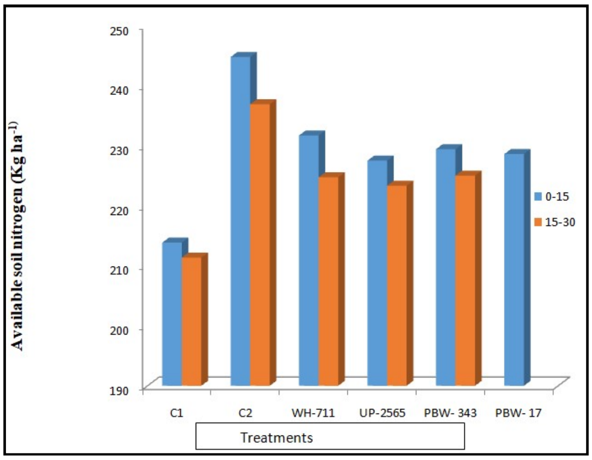

Fig. 4. Effect of open farming and *Eucalyptus* based agroforestry systems on available soil nitrogen, N (kg ha^{-1}) and their interaction at different profile depths 0 – 15 and 15 – 30 cm

Available soil Phosphorus: The data presented in Table 5, Fig 5 on soil available phosphorus showed variation under open farming and *Eucalyptus* based agroforestry systems. The soil phosphorus was 22.1 kg ha^{-1} at soil depth, 0-15 cm was not significantly different with control treatments.

The soil phosphorus at a soil depth 0-15 cm ranged from 19.5 to 20.5 kg ha^{-1} in different varieties of wheat. The highest soil phosphorus was recorded in PBW-343 varietyof wheat which differed non significantly at 5% level with available soil phosphorus of UP-2565, WH-711 and PBW-17.

Thesoil phosphorus at a depth of 15-30 cm was not significantly different with each other. The available phosphorus at this soil depth ranged from 17.8 to 18.6 kg ha^{-1} in different varieties of wheat. The highest available phosphorus of the soil was 18.6 kg ha^{-1} was in PBW-343 of wheat which differed non significantly at 5% level with available phosphorus of UP-2565, WH-711and PBW-17. The interaction between open farming and poplar based agroforestry systems, at different soil profile depths showed no significant effect on available soil phosphorus.

Table 5. Effect of open farming and *Eucalyptus* based agroforestry systems on available soil phosphorus kg ha^{-1} and their interaction at different profile depths 0 -15 and 15 – 30 cm

Treatments	Available Soil Phosphorus (kg ha^{-1})		
	Soil Depths (cm)		
	0-15	15-30	Mean
Main plot (Farming system)			
C_1 (Control without tree)	17.7	15.4	16.5
C_2 (Agroforestry system)	22.1	15.4	21.6
SEm±	0.5	0.5	
CD at 5%	**NS**	**NS**	
Sub- plot (Wheat Varieties)			
WH-711	19.8	18.2	19
UP-2565	19.5	17.8	18.6
PBW-343	20.5	18.6	19.5
PBW-17	20.4	18.5	19.4
SEm±	0.7	0.7	
CD at 5%	**NS**	**NS**	
CV	9.2	9.4	
Interaction	**NS**	**NS**	

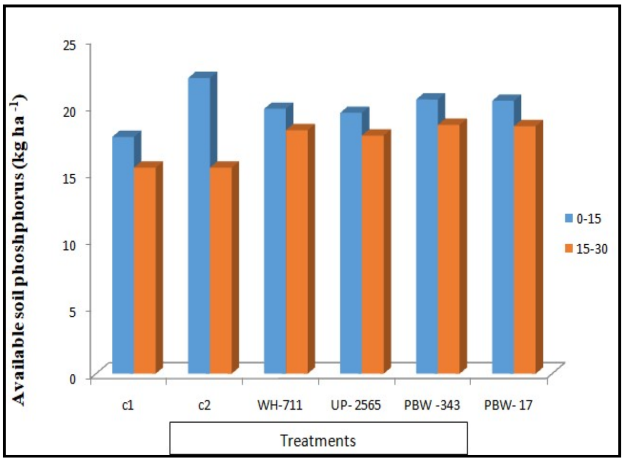

Fig 5. Effect of open farming and *Eucalyptus* based agroforestry systems on available soil phoshphorus kg ha^{-1} and their interaction at different profile depths 0 -15 and 15 – 30 cm

Available soil Potassium: The data presented in Table 6, Fig 6 on soil available potassium showed variation under open farming and *Eucalyptus* based agroforestry systems. The soil potassium was 211 kg ha^{-1} at soil depth of, 0-15 cm was not significantly different with each other. The soil potassium at a soil depth of 0-15 cm ranged from 186.6 to 201.2 kg ha^{-1} in different varieties of wheat.

Table 6. Effect of open farming and *Eucalyptus* based agroforestry systems on available soil potassium kg ha^{-1} and their interaction at different profile depths 0 -15 and 15 – 30 cm

Treatments	Available Soil Potassium P_2O_5 (Kg ha^{-1})		
	Soil Depths (cm)		
	0-15	15-30	Mean
Main plot (Farming system)			
C_1 (Control without tree)	182.4	174.0	178.2
C_2 (Agroforestry system)	211.1	201.4	206.2
SEm±	4.5	4.6	
CD at 5%	**NS**	**NS**	
Sub- plot (Wheat Varieties)			
WH-711	198.6	191.7	195.1
UP-2565	186.6	176.1	181.3
PBW-343	201.2	192.4	196.8
PBW-17	200.5	190.6	188.6
SEm±	6.3	6.6	195.5
CD at 5%	**NS**	**NS**	
CV	7.9	8.6	
Interaction	**NS**	**NS**	

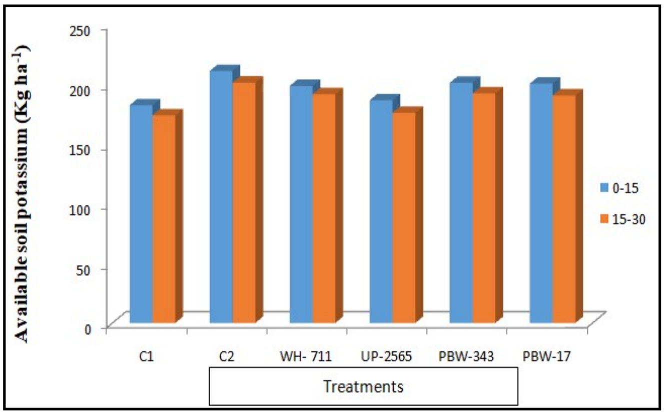

Fig. 6. Effect of open farming and *Eucalyptus* based agroforestry systems on available soil potassium kg ha^{-1} and their interaction at different profile depths 0 -15 and 15 – 30 cm

The highest soil potassium was recorded in PBW-343 varietyof wheat which differed non significantly at 5% level with available soil potassium of UP-2565, WH-711 and PBW-17. The soil potassium at depth15-30 cm was not significantly different with each other. It ranged from 176.1 to 192.4 kg ha^{-1} in different varieties of wheat. The highest available potassium of the soil was 192.4 kg ha^{-1} in PBW-343 of wheat which differed non significantly at 5% level with available potassium of UP- 2565, WH-711and PBW-17. The interaction between open farming and poplar based agroforestry systems, at different soil profile depths showed no significant effect on available soil potassium.

CONCLUSION

Soil pH varied significantly under both farming system at 0-15cm depth and non significant at 15-30cm depth. The higher soil pH was observed in plots under PBW-343 at a depth of 0-15cm and 15–30cm. Soil pH is observed higher under *Eucalyptus* based agroforestry system as compared to open farming system. Soil EC varied non significantly under both farming system at 0-15cm depth and significant at 15–30cm depth. The higher soil EC was observed in plots under PBW-343 variety. Soil EC is observed higher under *Eucalyptus* based agroforestry system as compared to open farming system. Soil organic carbon (%) varied non significantly under both farming system. The higher soil organic carbon was observed in plots under PBW-343 variety. Soil organic carbon is observed higher under *Eucalyptus* based agroforestry system as compared to open farming system. Available soil nitrogen was not influenced significantly under both farming system. Maximum soil nitrogen was observed in plots under WH-711 variety. Available soil nitrogen is observed higher under *Eucalyptus* based agroforestry system as compared to open farming system. Available soil phosphorus was not influenced significantly under both farming system. Maximum soil phosphorus was observed in plots under PBW-343 variety. Available soil phosphorus is observed higher under *Eucalyptus* based agroforestry system as compared to open farming system. Available soil potassium was influenced not significantly under both farming system. Maximum soil potassium was observed in plots under PBW-343 variety. Available soil potassium is observed higher under *Eucalyptus* based agroforestry system as compared to open farming system.

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