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Effect of different nutrient management modules on growth and yield of wheat under poplar based agroforestry system

Subrata Das and Manendra Singh

Abstract
The investigation aimed at study the effect of various nutrient sources on growth and yield of wheat crop under five years old poplar plantation. The experiment was laid on randomized block design with seven treatments, i.e., Control (T_1), recommended NPK (T_2), 150% of N and recommended P, K (T_3), recommended NPK + $ZnSO_4$ @25 kg/ha (T_4), 150% of N and recommended P, K + $ZnSO_4$ @25 kg/ha (T_5), recommended NPK + $ZnSO_4$ @25 kg/ha + FYM @10 t/ha (T_6) and 150% of N and recommended P, K + $ZnSO_4$ @25 kg/ha + FYM @10 t/ha (T_7). All the growth and yield related parameters of wheat crop was found significantly maximum in treatment T_7. Among the different nutrient modules T_7 produced grain yield (4.30 t/ha), straw yield (4.93 t/ha) and biological yield (9.23 t/ha).

Keywords: Agroforestry, nutrient management, wheat

Introduction
Agroforestry is a collective name for land use systems and practices in which woody perennials are deliberately integrated with crops and/or animals on the same land-management unit (ICRAF). The integration of trees, agricultural crops, and animals into an agroforestry model has the potential to enhance productivity, improve soil fertility, reduce erosion, improve water quality for crop, maintain the biodiversity, increase aesthetics, and sequester carbon (Nair *et al.,* 2009) [18]. The productive and protective role of agro ecosystems has also been emphasized by both the Millennium Ecosystem Assessment (2005) and the International Assessment of Agricultural Science and Technology for Development (2008). Agroforestry has been shown to provide a number of benefits to farmers by improving farm household resilience through additional products for sale or consumption (Thangata and Hildebrand, 2012) [17]. Agroforestry providing financial benefits to landowners and farmers for land-use practices that maintain environmental and ecological services of value to the wider society (FAO State of Food and Agriculture Report, 2007).

Cultivation of wheat (*Triticum aestivum* L.) as *Rabi* crop under the poplar the plantations is a common practice in *tarai* region and adjacent states of North Indian plains. Poplar shed their leaves in November when the growing season of wheat start and remains leafless until the end of March when wheat crop reaches maturity. It is also cultivated under rainfed conditions and the area near the tail end of canals where a shortage of water is often experienced. The average yield of wheat is quite low in such areas, which is mainly due to a shortage of water (Ashraf, 1998) [19]. As no additional land is available for wheat area expansion, this increase in wheat production has to come through increased yield per unit of production area. However, the production data for wheat in India shows no significant increase in productivity over last ten years (2000–2010) (Fertilizer Statistics, 2010–11) [22].There is a gradual yield reduction (10–46%) of wheat, grown under poplar, with the increase in age of trees (first–sixth year). Such yield loss is often compensated by the sale of poplar wood at the end of the rotation (Gill *et al*., 2007). Karnataka (1996) [21, 20] emphasized that poplar can be grown on a short rotation of 5-7 years and the farmers need not to wait for long in realizing the returns and they can make use of interspace of fruit plants judiciously for economic gains. Cultivation of wheat in combination with trees provide double benefits in terms of crop yield as well as tree products. Agroforestry can reap substantial benefits both economically and environmentally, producing more output and proving to be more sustainable than forestry or agricultural monocultures.

Materials and Methods

Experimental Site

The field experiment was conducted during *Rabi* season of 2016-17 at experimental site of Agroforestry Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand. Under the poplar plantation wheat variety PBW-154 sown in line in the bed size of 5m x 5m. Each experimental plot included 21 trees.

Treatment details

The investigation was conducted from November, 2016 to April, 2017 by taking 7 treatments with 3 replications under randomized block design.

T1: Control
T2: Recommended NPK (120:60:40)
T3: 150% of N and recommended P, K
T4: Recommended NPK + $ZnSO_4$ @25 kg/ha
T5: 150% of N and recommended P, K + $ZnSO_4$ @25 kg/ha
T6: Recommended NPK + $ZnSO_4$ @25 kg/ha + FYM @10 t/ha
T7: 150% of N and recommended P, K + ZnSO4 @25 kg/ha + FYM @10 t/ha

Proper fertilization is a critical factor in producing optimum and profitable wheat yields**.** ½ N, full P&K were applied as basal. Rest of N were applied in two split applications at (crown root initiation) CRI & heading stage equally. ZnSO4, $7H_2O$ were applied as basal. FYM was incorporated 15-20 days before sowing at the time of final land preparation. First irrigation was given at CRI stage and milking stage of crop, remaining water requirement full fill by rain received during the season.

Growth parameters recorded 1m running length from all the plots of each treatment and each replication. Emergence count and root length of wheat was recorded at 30 days after sowing. Shoot length were measured at 30, 60, 90, 120 days after sowing. Number of tillers at various stages of development of wheat crop were recorded at 60, 90 and 120 days after sowing. For yield parameter, length of spike, number of grains per spike, test weight and biological yield of wheat is recorded under poplar based agroforestry system. Economics of Wheat + Poplar agroforestry system was calculated by estimating cost of cultivation, net returns and gross returns in current scenario of market price during the experimental period (November 2016 to April 2017).

Results and Discussion

Growth parameters of wheat under poplar based agroforestry system

Shoot length

The data pertaining to the emergence count of wheat not affected by various treatments are presented in Table 2 The highest emergence count of wheat per meter square was recorded T_7 and the lowest value of emergence count of wheat per square meter T_3. Almost no difference was recorded in emergence count per meter square may be due to the fact that there was no significant influence of the nutrient sources on emergence of wheat. Ram *et al.* (2017) [16] also reported that the emergence count of wheat was not significantly influenced with the varying nitrogen levels.

Table 1: Emergence counts of wheat under poplar based agroforestry system

Treatment	Emergence count of wheat per m^2
T_1 (Control)	103.7
T_2(Recommended NPK)	106.0
T_3(150% of N and recommended P, K)	102.0
T_4 (Recommended NPK + $ZnSO_4$ @25 kg/ha)	105.0
T_5 (150% of N and recommended P, K + $ZnSO_4$ @25 kg/ha)	106.0
T_6 (Recommended NPK + $ZnSO_4$ @25 kg/ha + FYM @10 t/ha)	104.3
T_7 (150% of N and recommended P, K + $ZnSO_4$ @25 kg/ha + FYM @10 t/ha)	106.3
SEm ±	5.36
C.D. at 5%	NS

All the treatments had significantly increased the shoot length of wheat at various stages of crop growth (30, 60, 90 and 120 DAS) over T_1.The lowest value of shoot length was recorded in T_4. Maximum shoot length in treatment T7 and T6 may be due to the effect of higher dose of fertilizer and also due to the effect of FYM. Similar trend response were also observed by Kashem *et al.* (2015), who also reported that as compared to control, application of higher rate of vermicompost (20 t ha^{-1}) and NPK fertilizer (200%) showed an increase of 36.34 cm and 23.34 cm of shoot length respectively. Abede and Abede (2016) also reported that plant height in wheat was influenced by fertilizer application.

Table 2: Effect of different nutrient management practices on shoot length (cm) of wheat under poplar based agroforestry system

Treatments	Days after sowing			
	30	60	90	120
T1	20.71	38.87	66.07	72.83
T2	26.68	54.60	82.37	89.30
T3	26.62	57.67	88.17	95.37
T4	24.43	51.20	88.13	96.27
T5	26.31	59.00	92.63	101.33
T6	27.59	63.33	97.20	103.17
T7	28.39	64.27	92.37	101.40
SEm±	0.521	2.57	2.239	1.480
CD at 5%	1.624	8.00	6.976	4.611

Root length

The data pertaining to the root length of wheat at 30 DAS as affected by various treatments, are presented in Table 3.

Table 3: Effect of different nutrient sources on root length (cm) of wheat under poplar based agroforestry system

Treatments	Root length of wheat 30 DAS
T_1	7.18
T_2	8.40
T_3	8.55
T_4	8.70
T_5	8.88
T_6	9.05
T_7	9.16
SEm±	0.133
CD at 5%	0.416

Number of tillers

All the treatments had significantly increased the tiller number at various stages of growth (60 DAS, 90 DAS and 120 DAS) as compared to T_1. The maximum numbers of tiller observed at 60 DAS from the treatment T7 which was at par with T6 and lowest value of tiller number was observed from treatment T2 followed by T3.Similar trend response were also observed in tiller numbers at 90 DAS. In case of data related to tiller numbers at 120 DAS, maximum number of tillers was observed from the treatment T7 followed by T6 and lowest value of tiller number was observed from T2 followed by T3 among the fertilizer treatments.

Table 4: Effect of various nutrient management practices on number of tillers of wheat under agroforestry system

Treatments	Days after sowing		
	60	90	120
T1	0.43	0.50	0.43
T2	2.27	2.37	2.20
T3	2.73	2.97	2.70
T4	2.83	2.90	2.97
T5	2.93	3.10	3.13
T6	3.90	4.00	4.27
T7	4.17	4.23	4.43
SEm±	0.214	0.243	0.148
CD at 5%	0.668	0.758	0.462

Jalil *et al*. (2017) [14] also observed that integrated nutrient management significantly increased the number of tillers per m^2 and maximum number of tillers per m^2 was recorded from treatment combination of rock phosphate @100 kg ha^{-1} + FYM @5 t/ha. Zafar *et al.* (2016) [9] also reported that nutrients in combination or alone have significant effect on productive tiller per plant.

Yield Parameters

Spike length

The effect of various treatments was found significant on the spike length of wheat. The highest spike length was recorded from treatment T7.The significant increase in spike length might be due to the effect of zinc on the plant. Abe be and Abede (2016) reported that fertilizer application 30 days after sowing showed 2.8 cm increment in length of spike as compare to control. Similar trend response were also observed by Siavoshi *et al.* (2011) [8] who reported that application of inorganic fertilizers along with manure increased the panicle length of rice. Arif *et al.* (2017) [12] also reported that application of potassium @375 kg/ha and zinc @15 kg/ha affected the spike length of wheat as compare to control.

No. of spikelets/spike

The effect of different treatments was found significant on numbers of spikelets per spike of wheat crop over control. The significant increase in numbers of spikelet per spike might be due to the effect of zinc on wheat crop. Narkhede *et al.* (2015) [13] reported that maximum number of spikelet per spike were recorded from treatment RDF+5 t FYM ha^{-1} +10 kg $ZnSO_4$ ha^{-1} + 5 kg boron ha^{-1}.

No. of grains/spike

The effect of different treatments was found significant on number of grains per spike over control. The maximum numbers of grains per spike in T7 treatment due to the fact that maximum no of spikelets per spike which may be due to the effect of zinc sulphite on crop. Similar trend response were observed by Arif *et al.* (2017) [12] who reported that the potassium level of 375 kg/ha and zinc 15 kg/ha produced the highest grains per spike of wheat. Kumar *et al.* (2017) [11] reported that the maximum no. of grains were recorded from the treatment 100% RDF+2.5 t VC + 20 kg $ZnSO_4$ ha^{-1}. Number of grains per spike were also increased by integrating FYM and vermicompost or supplementary nutrients like, zinc with NPK.

1000-grain weight

All the treatments showed significant effect on 1000-grain weight over control. The highest value of 1000-grain weight was obtained from the treatment T7 which was at par with rest of the treatments over control. The results were in accordance with the findings of Zafar *et al.* (2016) [9], who also reported that application of Zn and K through soil and foliar means significantly improves the fertile spikelets $spike^{-1}$, spike length and 1000 grain weight. Abede and Abede (2016) also reported that fertilizer applied 30 days after sowing has 16% more 1000-seed weight than the treatments with no fertilizers.

Table 5: Effect of various nutrient management practices on yield attributing characters of wheat under poplar based agroforestry system

Treatment	Spike Length(cm)	No. of spikelets /spike	No. of grains /spike	1000- grain weight (g)
T1	12.70	15.80	13.17	42.17
T2	14.13	18.43	15.70	44.70
T3	14.33	18.53	15.83	44.77
T4	15.67	20.43	17.53	45.10
T5	15.90	20.57	17.70	45.20
T6	16.30	20.77	18.97	45.63
T7	16.40	21.17	19.17	45.97
SEm±	0.525	0.540	0.388	0.568
CD at 5%	1.635	1.682	1.209	1.771

Yield

Yield attributes such as grain yield, straw yield, biological yield and harvest index are presented in table no. 5.

Grain yield

All the treatments had significantly increased the grain yield over control. The maximum grain yield of 4.3 t/ha was recorded from the treatment T7 which was at par with T6 (4.22 t/ha) and the lowest value of grain yield was recorded from the treatment T2 (2.65 t/ha) followed by T3 (2.88 t/ha) among the fertilizer treatments. The maximum grain yield in T7 and T6 might be due to higher doses of fertilizer application along with incorporation of FYM. The results were in accordance with the findings of Siavoshi *et al.* (2011) [8] who reported that application of chemical fertilizer in combination with organic fertilizer @1.5 t/ha increased the rice yield significantly. Similar results were also reported in soybean by Bandyopadhyay *et al.* (2010) [6] who found that application of FYM @4 t/ha in combination with recommended dose of fertilizers (NPK) significantly improved the grain yield of soybean by 14.2 per cent over NPK alone and by 50.3 per cent over control treatment. Similar trend responds in rice were also reported by Gosal *et al.* (2018) [7].

Straw yield

The maximum straw yield of 4.93 t/ha was recorded from the treatment T7 which was at par with T6 (4.82 t/ha) and the lowest value of straw yield was recorded from the treatment T2 (3.38 t/ha) followed by T3 (3.61 t/ha) among the fertilizer treatments. Maximum straw yield in T7 and T6 treatments might be due to the effect of FYM in combination with inorganic fertilizer which led in higher straw yield of the crop. The results were in conformity with Roy *et al.* (2017) [4] who reported that application of 100% NPK fertilizer, green manuring with dhaincha, $ZnSO_4$, and azophos gives maximum grain and straw yield of rice (4.56 and 5.13 t/ha of grain and straw yield, respectively). Dubey *et al.* (2017) [5] also reported that significantly highest grain and straw yield recorded from the combination of 150 Kg N+ 75Kg P_2O_5+ 75 Kg K_2O + 40kg S +FYM 5 t/ha.

Biological yield

Effect of different treatments was found significant on the biological yield of the wheat crop. All the treatments had significantly increased the biological yield over control. The maximum biological yield of 9.23 t/ha was recorded from the treatment T7 which was at par with T6 (9.03 t/ha) and the lowest value of biological yield was recorded from the treatment T2 (6.04 t/ha) followed by T3 (6.49 t/ha) among the fertilizer treatments. Maximum biological yield in T7 treatment might be due to the fact that increase in grain as well as straw yield because of higher doses of fertilizer and incorporation of FYM which led in maximum biological yield of the crop. Arif *et al.* (2016) [3] reported that addition of FYM and N fertilizer significantly increased the biological yield of maize. Similar results were also reported by Singh *et al.* (2018) [2].

Harvest Index

Effect of different treatments was also found significant on the harvest index of the wheat crop under poplar based agroforestry system. All the treatments had significantly increased the harvest index over control. The maximum harvest index was recorded from the treatment T6 (46.7%) which was at par with T7 (46.6%), T4 (46.3%), T5 (46.2%) and T3 (44.5%) and the lowest value of harvest index was recorded from the treatment T2 among the fertilizer treatments. Maximum value of harvest index in T6 treatment may be due to the fact that grain yield was not much lesser than the straw yield of the crop.

Table 6: Effect of various nutrient management practices on yield of wheat under poplar based agroforestry system

Treatments	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest Index (%)	Percent yield increase over control
T1	1.89	2.68	4.57	41.4	_
T2	2.65	3.38	6.04	43.9	28.68
T3	2.88	3.61	6.49	44.4	52.38
T4	3.60	4.18	7.78	46.3	90.48
T5	3.69	4.31	8.00	46.1	95.24
T6	4.22	4.82	9.03	46.7	123.28
T7	4.30	4.93	9.23	46.6	127.51
SEm±	0.165	0.103	0.156	0.733	_
CD at 5%	0.513	0.302	0.486	2.283	_

Percent yield increase over control

The percent yield increase on various treatments as compared to control were found maximum on treatment T7 (127.51%) followed by T6 (123.28%) and lowest value was found in T2 (28.68%) among different nutrient management modules.

Growth parameter of poplar tree under poplar-wheat agroforestry system

The height of the tree before sowing of crop was found almost similar but the data of tree height after harvest showed significant increase in tree height and maximum tree height increment was found in treatment T_7 and T_6 and lowest value of tree height increment was found in T_2 among the fertilizer treatments. The tree diameter increment was found highest in T_7 and lowest value of tree diameter increment was found in T_2 and T_3 among the fertilizer tretments.

Table 7: Effect of different levels of nutrients on tree height, tree diameter and volume of trees

Treatments	Tree height (m)			Tree diameter (cm)			Tree volume (m^3)			% Increase in volume
	Before sowing of crop	After harvest of crop	Height increment in 5 month periods	Before sowing of crop	After harvest of crop	Diameter increment in 5 month periods	Before sowing of crop	After harvest of crop	Volume increment	
T1	13.01	13.37	0.36	18.01	18.66	0.65	0.1467	0.1611	0.0144	9.83
T2	13.26	13.64	0.38	18.19	18.92	0.74	0.1516	0.1679	0.0163	10.77
T3	13.40	13.78	0.38	18.22	18.96	0.74	0.1544	0.1710	0.0165	10.70
T4	13.26	13.68	0.41	18.25	19.09	0.84	0.1526	0.1713	0.0187	12.28
T5	13.31	13.73	0.42	18.51	19.35	0.84	0.1583	0.1774	0.0191	12.05
T6	13.29	13.76	0.47	18.54	19.38	0.84	0.1594	0.1792	0.0198	12.45
T7	13.32	13.79	0.47	18.83	19.68	0.85	0.1628	0.1830	0.0202	12.40

Poplar deltoides plantation was established during February, 2012 with spacing of 7m x 3m. Tree growth (height, diameter and volume increment) was recorded during the course of investigation. Tree volume increment was observed maximum in treatment T_7 and lowest in T_2 among the fertilizer treatments. The percent increase in volume was found maximum i.e., 12.45% in treatment T_6. The increase in tree growth parameters may be due to the effect of different doses of fertilizers and also due to effect of FYM on trees. Rivest *et al.* (2010) [1] reported that poplar biomass increment was significantly higher in the intercropping than the harrowing treatment.

Conclusion

From the study it can be concluded that the growth and yield of wheat crop was influenced greatly by various nutrient management practices. From yield point of view, recommended P, K + $ZnSO_4$ @25 kg/ha + FYM @10 t/ha (T_7) was the best as compared to other treatments. Growth parameters of poplar was also got influenced to a considerable extent.

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