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Optimization of sowing time of different wheat varieties under poplar based agroforestry system

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Abstract
A field experiment was conducted during *rabi* season of 2015-16 at Experimental site of Agroforestry Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar dist. US Nagar, India to study the performance of different wheat varieties (DPW-621-50, UP-2628, UP-2526 and UP-2565) under open and poplar based agroforestry system on different date of sowing (4th November, 24th November and 14th December). The study indicated that normal date of sowing (24th November) was much suitable for getting higher yield of wheat under open farming as well as under agroforestry systems in the *tarai* region of Uttarakhand.

Keywords: Agroforestry, date of sowing, wheat variety, open farming

Introduction
India is predominantly an agricultural country as most of its population lives in villages and depends mainly on agriculture and its subsidiary enterprises. The pressure on land resources has increased many folds in recent years as a result of population explosion and associated demands. Many people regard agroforestry as a logical solution for sustainability as it serves the problems of fuel wood shortage and degradation of marginal agricultural land. A major assumption behind this view is the intercropping trees with arable crops substantially increase biomass production per unit area due to greater utilization of solar energy.

Agroforestry is a dynamic, ecological based, natural resources management system that, through the integration of trees on farms and in the agricultural landscape, diversifies and sustains production for increased social, economic and environmental benefits, for land users at all levels (ICRAF). Agroforestry helps in the sustainability of agriculture and its diversification to attain higher benefits per unit area of land, when carefully selected and managed with the introduction of fast growing multipurpose trees with little effect on agriculture crops (Johl *et al.*, 1986) [1]. It can control runoff thereby reducing soil erosion, reducing losses of water, soil material, organic matter and nutrients. It also can increases and maintains soil organic matter and biological activity at levels satisfactory for soil fertility. Agroforestry has become an important land-use system that not only fulfils the food and wood requirement of the local people, but also protects earth from environmental hazards. Agroforestry leads to a more diversified and sustainable production system than many treeless alternatives and provides increased social, economic, and environmental benefits for land users at all levels (Sanchez, 1995 and Fay *et al*., 1998) [2, 3].

Populus deltoides based agroforestry system is one of the viable alternate land use system which prevents further degradations of soil, provide higher biological production on sustainable basis and ameliorate the environment. Under the poplar based agroforestry system, poplar exhibited significant impact on available soil nitrogen, phosphorus, potassium, calcium and magnesium through litter fall at the age of three to four years (Chauhan *et al*., 2012)[4].

Wheat (*Triticum aestivum* L.) is the world's most widely cultivated cereal crop. It is the most important staple food of about two billion people (36% of the world population). Worldwide, wheat provides nearly 55% of the carbohydrates and 20% of the food calories consumed globally (Breiman and Graur, 1995) [5].

Planting date is one of the major factors which determine the ability of the crop varieties to stand against different environmental conditions. Appropriate sowing date is important to have the crop in the field, when environmental conditions are conducive for growth and development.

Different planting dates affect seed development, quality and yield of wheat. Besides planting time choice of cultivar is also important in achieving the higher yield. Genetic potential of variety is better expressed under a proper environmental condition. Agroforestry system helps in maintaining a suitable microclimate for crop growth. Selection of proper cultivar under agroforestry system is important to fetch a higher yield under agroforestry based cropping system.

As planting time and cultivar are crucial factors for obtaining desirable wheat yield so an experiment was conducted to optimize the date of sowing of four wheat varieties and to study the growth and yield attributes under open and poplar based agroforestry system, under *tarai* region of Uttarakhand.

Material and Methods

Experimental site

The field experiment was conducted during *rabi* season of 2015-16 at experimental site of Agroforestry Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar, Distt. Udham Singh Nagar, Uttarakhand. Pantnagar is located at 29^0 N latitude, 79°30' E longitude and at an altitude of 243.8 m above the mean sea level at foot hill of shivalik range generally called *tarai* region.

Climate and soil

The climate of the study area is humid sub-tropical with cold winters and hot dry summers. The maximum temperature in summer sometimes may reach up to 42^0C and minimum temperature in winter may occasionally fall down to 0.5^0C. Monsoon sets in the second or third week of June and heavy down pour mostly occur in July and August and monsoon continues up to the end of September. The average annual rainfall is about 1450 mm, of which 80-90 per cent is mostly received during the rainy season (July to September).

The soil of *tarai* region is alluvial, medium to moderately coarse textured materials under predominant influence of tall vegetation and moderate to well drain. The soil has weakly developed with mollic epipedons and horizons and is classified as Mollisols

Experimental Details

The experiment was laid out in a split plot design with three replications. The poplar trees were planted on February 22, 2012 with a spacing of 7 m × 3 m. the wheat was sown at a spacing of 20 cm from row to row and 100 kg seeds were require for a hectare of land. The different wheat varieties were sown on different dates to evaluate the effect of different sowing dates on yield of wheat under agroforestry system.

Treatment Details:

Sowing dates (Main plot)

D_1 : 4th November 2015
D_2 : 24th November 2015
D_3 : 14th December 2015

Wheat varieties (Sub-plot)

V_1 : DPW-621-50 (Timely sown variety)
V_2 : UP-2628 (Timely sown variety)
V_3 : UP-2526 (Timely sown variety)
V_4 : UP-2565 (Timely sown variety)

Results and Discussion

Yield and Yield Attributes

The yield and yield contributing characters are discussed under following heads.

Number of effective Tillers

The highest number of tiller (510 m^{-2}) under agroforestry system was recorded on 24th November sown wheat which is significantly higher than the other dates of sowing (Table 1). The lowest number of tiller was recorded on 14th December sown wheat. Under different wheat variety UP-2565 gave highest (490 m^{-2}) number of tiller which was statistically *at par* with DPW 621-50.The lowest number of tiller (440 m^{-2}) was observed in UP- 2526.

Higher metabolic activity along with longer vegetative period in the early sown crop may be responsible for higher tiller number compared with that in late sown crop. Kohli *et al.* (1997) [6] also reported that delay in sowing of wheat under poplar plantation coincides with leaf shedding of poplar, which hinders the germination and emergence of wheat crop that ultimately results in the lesser number of tillers. Reduction in tillers count under poplar based agroforestry system as compared to open farming system also reported by Mishra *et al.* (2010) [7].

Number of spike m^{-2}

Variation in number of spike m^{-2} due to different date of sowing and varieties were found significant (Table 1). The maximum numbers of spikes (458.6 m^{-2}) were recorded on 24th November sown wheat which was significantly higher than other dates of sowing. The lowest spikes (337.5 m^{-2}) were observed on 14th December sown wheat.

Among different varieties UP-2565 gave highest numbers of spikes (416.1 m^{-2}) which was significantly higher over all other varieties except DPW 621-50. The interaction between the sowing date and wheat varieties was found non-significant in terms of number of spike m^{-2}.

Present study revealed that timely sown condition brought higher number of spike m^{-2} as compared to late sown condition. This might be due to prevailing of favourable temperature required for wheat crop for higher photosynthate accumulation consequently resulting in higher yield parameters in 24th November. This results are in conformity with the findings of Mukherjee (2012) [8]. Sowing in 14th December exposed the crop to higher temperature and longer day length during tillering and grain filling period, which might have reduced the tiller number. Hossain and Alam (1986) [9] also observed reduction in ear number due to late planting of wheat.

Spike length

Variation in spike length due to different date of sowing and varieties were found to be significant. The maximum spike length (10.5 cm) was recorded for 24th November sowing which was significantly superior over the other sowing dates. The lowest spike length (9.0 cm) was recorded on 14th December sown wheat.

Among the different wheat varieties the maximum spike length (10.3 cm) was recorded in variety DPW 621-50 which was statistically superior over all the varieties except UP-2565 which was otherwise at par. The lowest spike length (9.3 cm) was recorded in variety UP- 2526.The interaction effect between the sowing date and wheat varieties was found to be non-significant in terms of spike length.

Length of the spike was lower in agroforestry system as compared to open farming system. This reduction may be due to lower production of photosynthates under low light conditions (shading effect) as the light intensity depressed due to closer of canopies of trees. Similar effect was also observed by Patil *et al.,* (2002) [10] on winter wheat planted along with

eucalyptus crop. Crop sowing on normal sowing date (24th November) showed better results as compared to all other sowing dates. The minimum spike length was found in late sowing (14th December). This is mainly due to reduction in reproductive phase and higher temperature prevailing during spike formation. Similar effect of delayed sowing on ear length of wheat was also reported by Piech and Atankowski (1989) [11] in different winter wheat varieties.

Number of fertile spikelet spike^{-1}

Variation in number of fertile spikelet spike^{-1} due to different date of sowing and varieties were found significant. The highest number of fertile spikelet (17spike^{-1}) was found on 24th November sown wheat which was significantly higher over other dates. The lowest number of fertile spikelet (14.1spike^{-1}) was recorded with 14th December sown wheat.

Among the different varieties DPW 621-50 gave highest fertile spikelet (16.7spike^{-1}) which was significantly higher over other varieties except UP-2565 which was otherwise at par. The lowest fertile spikelet (14.9 spike^{-1}) was recorded in variety UP-2526.The interaction effect between the sowing date and wheat varieties was found non-significant in terms of fertile spikelet spike^{-1}.

The highest number of fertile spikelet spike^{-1} was found on 24th November sowing while the lowest number of fertile spikelet spike^{-1} was found on 14th December sowing. The variation in number of fertile spikelet may be probably due to variation in temperature during the spikelet differentiation. Similarly, Zhang (1989) [12] also reported that timely sowing can prolong the period of spike differentiation and increase the number of fertile spikelet. Among varieties, DPW 621-50 produced more number of fertile spikelet than other varieties. It may be due to genetic potential of the genotype. Number of fertile spikelet spike^{-1} was found to be lower in agroforestry system as compared to the open system. This might be due to the shading effect of poplar trees which reduced the intensity of light under the agroforestry system.

Number of Grains spike^{-1}

Different date of sowing significantly influenced the number of grains spike^{-1} of wheat (Table 2). Significantly maximum number of grains spike^{-1} (42.7) was recorded on 24th November sown wheat which was significantly higher than other date of sowing. The minimum number of grains spike^{-1} (37.4) was recorded on 14th December sown wheat. The effect of wheat varieties on number of grains spike^{-1} was found non-significant. The interaction effect between the sowing date and wheat varieties was also found non-significant in terms of number of grains spike^{-1}.

Less number of grains spike^{-1} in late sowing was due to less production of photosynthates due to shorter growing period. These results are in line with those of Shahzad *et al.* (2002) [13] who also got the same results. Number of grains spike^{-1} under poplar based agroforestry system was found lower as compared to open farming system. It might be due to competition between the tree and crop for light, moisture, nutrient, etc. and modification of micro-environment conditions (Chauhan *et al.*, 2012) [4].

Grains weight spike^{-1}

The effect of sowing dates on gain weight spike^{-1} was found significant. The maximum grains weight spike^{-1} (2.0 g) was found on 24th November sown wheat which was significantly higher than other dates of sowing. The lowest gain weight spike^{-1} (1.6 g) was observed on 14th December sown wheat. Among different varieties DPW 621-50 gave significantly higher number of grains weight spike^{-1} (1.9 g) which was at par with UP-2565.the lowest gain weight spike^{-1} (1.7 g) was observed in UP-2526 and UP-2628. The interaction effect between the sowing date and wheat varieties was also found non-significant in terms of grains weight spike^{-1}. The 24th November sowing resulted in better development of the grains due to longer growing period. Similar results were also reported by Spink *et al.* (2000) [14].

Test weight

The effect of different sowing dates and varieties was significant on 1000 seeds (Test weight). Sowing on 24th November resulted in more test weight (45.6 g) of seeds. Test weight was found lower in case of agroforestry system as compared to the open system. Among various varieties DPW 621-50 produced significantly higher test weight (44.5 g) as compared to the other varieties. The lowest test weight (41.6 g) was produced by UP-2628. The interaction effect on different sowing dates and varieties found significant in relation to test weight (Table 4). All the variety perform well, when sown on 24th November while in case of different varieties DPW-621-50 gave highest test weight (48.4g) followed by UP-2565 (45.5g).

Grain yield

Grain yield of wheat was significantly affected by different sowing dates and varieties (Table 2). Among various sowing dates maximum grain yield (39.5 q ha^{-1}) was found on 24th November sown wheat, which was also significantly superior over other two sowing dates. The lowest grain yield (32.9 q ha^{-1}) was recorded on 14th December sown wheat. Higher grain yield was recorded under open condition as compared to agroforestry system.

Among the different varieties, DPW 621-50 produced the maximum grain yield (38.5 q ha^{-1}) which was significantly superior over other varieties except UP-2565 which was otherwise at par. The lowest seed yield (33.8 q ha^{-1}) was found in variety UP-2526.

The interaction of different date of sowing and varieties was found significant on grain yield (Table-4). Variety DPW-621-50 gave highest yield on 4th (38.2 q ha^{-1}) and 24th (43.3 q ha^{-1}) November sown wheat which was significantly higher than other variety except UP-2565 which was otherwise at par in both the dates. In case of 14th December sown wheat Up-2665 gave highest yield (35.1 q ha^{-1}) than other variety except DPW-621-50 and UP-2526 which were otherwise at par. The lowest gain yield (32.3 q ha^{-1}) was reported by variety UP-2526 under late sown condition (14th December).

Lower grain yield in late sown wheat was mainly due to less number of tillers m^{-2}, less number of grains spike^{-1} and lower 1000 grain weight. These results are in accordance with the finding of Spink *et al.* (2000) [14] and Aslam *et al.* (2003) [15]. Higher grain yield in DPW 621-50 was mainly due to higher number of tillers and higher 1000-grain weight. These results are in corroboration with the finding of Shahzad *et al.* (2002) [13].

Table 1: Number of spikes m^{-2}, spike length, fertile and sterile spikelets $spike^{-1}$ and tillers (m^{-2}) as influenced by sowing dates and varieties at harvest

Treatments	No. of tillers (m^{-2}) at harvest	No. of spike (m^{-2})	Spike length (cm)	No. of fertile spikelet $spike^{-1}$
	AFS (open)*	AFS (open)*	AFS (open)*	AFS (open)*
Date of sowing				
4th November	452.5(497.5)	391.3(438.3)	9.9(10.7)	15.5(16.7)
24th November	510.0(547.5)	458.6(498.1)	10.5(11.1)	17.0(18.2)
14th December	434.2(472.1)	337.5(387.0)	9.0(9.8)	14.1(15.3)
S.Em±	4.4	4.7	0.06	0.5
CD at 5%	17.2	18.5	0.2	1.8
Wheat varieties				
DPW-621-50	485.6(525.0)	413.9(457.5)	10.3(10.9)	16.7(17.6)
UP-2628	446.1(487.0)	377.8(423.5)	9.5(10.2)	15.0(16.2)
UP-2526	440.6(485.2)	375.6(423.2)	9.3(10.1)	14.9(16.2)
UP-2565	490.0(525.7)	416.1(460.3)	10.1(10.8)	15.7(16.9)
S.Em±	8.1	6.7	0.1	0.3
CD at 5%	21.0	20.0	0.4	1.0

* Figures in parentheses are of open condition without trees.
NS = Non-significant

Table 2: Number of grain $spike^{-1}$, grain weight $spike^{-1}$ (g), test weight (g) and grain yield (q ha^{-1}) as influenced by different treatments at harvest

Treatments	No. of grain $spike^{-1}$	Grain weight $spike^{-1}$ (g)	Test weight (g	Grain yield (qha^{-1})	
	AFS (open)*	AFS (open)*	AFS (open)*	AFS (open)*	% reduction over open
Date of sowing					
4th November	40.3(44.9)	1.8(2.0)	43.2(46.2)	36.2(40.9)	11.5
24th November	42.7(47.2)	2.0(2.2)	45.6(48.2)	39.5(45.0)	12.2
14th December	37.4(42.0)	1.6(1.9)	42.0(45.1)	32.9(36.8)	10.6
S.Em±	0.6	0.01	0.6	0.3	
CD at 5%	2.0	0.05	2.5	1.3	
Wheat varieties					
DPW-621-50	41.6(46.0)	1.9(2.1)	44.5(47.5)	38.5(43.5)	11.5
UP-2628	39.7(44.1)	1.7(2.0)	41.6(44.2)	34.4(38.9)	11.6
UP-2526	38.4(43.5)	1.7(1.9)	42.8(45.6)	33.8(38.6)	12.4
UP-2565	40.8(45.2)	1.8(2.1)	44.3(47.1)	37.9(42.5)	10.8
S.Em±	0.8	0.03	0.6	0.6	
CD at 5%	NS	0.08	1.7	1.7	

* Figures in parentheses are of open condition without trees.
NS = Non-significant
AFS= Agroforestry System

Table 3: Interaction effect between sowing dates and varieties in respect of test weight (g)

Sowing Dates	Varieties			
	DPW 621-50	UP-2628	UP-2526	UP-2565
4th November	44.3	42.9	41.9	43.8
24th November	48.4	44.7	43.6	45.5
14th December	409	40.1	42.9	44.3

S.E.m ± C.D. (P= 0.05)

1. For comparing sowing dates of same varieties	0.9	2.9
2. For comparing different varieties at same sowing date	1.0	3.5

Table 4: Interaction effect between sowing dates and varieties in respect of grain yield (q ha^{-1})

Sowing Dates	Varieties			
	DPW 621-50	UP-2628	UP-2526	UP-2565
4th November	38.2	35.2	34.4	36.9
24th November	43.3	38.1	34.8	41.9
14th December	34.2	29.7	32.3	35.1

S.E.m ± C.D. (P= 0.05)

1. For comparing sowing dates of same varieties	1.0	2.9
2. For comparing different varieties at same sowing	0.9	2.9

Conclusion

From the given study it may be concluded that 24th November sowing is suitable for getting higher yield both in open as well as under agroforestry system. Among different wheat varieties DPW-621-50 and UP-2565 perform well and both are equally effective for cultivation in *tarai* condition of Uttarakhand under agroforestry system as well as in open condition.

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