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Effect of Intercropping Systems and Different Levels of Nutrients on Dry Matter Accumulation and Physiological Growth Parameters of Bed Planted Wheat (*Triricum aestivum* L.)

Madhulika Pandey* and Thakar Singh

Department of Agronomy, Punjab Agricultural University, Ludhiana-141004, Punjab, India; pandey.madhulika@hotmail.com

Abstract

The field experiment was conducted on bed planted wheat in a split-plot design with three replications at the research farm, Department of Agronomy, Punjab Agricultural University, Ludhiana during rabi seasons of 2012-13 and 2013-14. The main plots treatments involved five intercropping systems i.e. wheat + spinach, wheat + fenugreek, wheat + oats fodder, wheat + canola and wheat + linseed. Each main plot was divided into four sub plots to allocate the different levels of recommended dose of nutrients i.e. 0, 50, 75 and 100 % of recommended dose of nutrients to intercrops. But the nutrients applied to the intercrops did not affect the dry matter accumulation and physiological growth parameters (CGR, AGR and RGR) of wheat. Among the different intercropping systems, canola was found to be more aggressive and competitive to wheat than the other component crops and significantly lowered the dry matter accumulation, CGR and AGR than the other intercropping systems.

Keywords: AGR, CGR, Dry Matter Accumulation, Intercropping Systems, RGR, Wheat

1. Introduction

Growth is a vital function of plants and indicates the gradual increase in number and size of cells. The processes of growth and development are begin with germination followed by series of complex morphological and physiological events[1]. The most important resources used by crops during its growth period are usually light, water, and nutrients[2]. Raising productivity through more effective utilization of available resources (e.g. light, water, fertilizer, etc.), is possible through intercropping which resulted to reduction in weed pressure and sustain plant health[3]. Intercropping is a very profitable approach especially for the small land holders. Component crops in intercropping systems uses the same resources in different forms (e.g., non-leguminous crops uptake N in the form of nitrate (NO_3^-) while leguminous crops uptake the molecular nitrogen (N_2) which is fixed in root nodules by bacteria), thus reducing competition for soil N[4]. Intercropping is an intensive land use system with an objective to utilize the space between the rows of main or base crop and to produce more produce/unit area. The space between the rows could be effectively utilized by growing a short duration crop, which may generate an additional income without adversely affecting the yield of principal crop. In single species cropping systems, individuals can be expected to have adapted similar strategies to fulfill those requirements, whereas plants in a multi-species system can have different resource requirements, and possess different biological and physical strategies for

**Author for correspondence*

acquiring nutrients[5,6]. Previous studies have shown significant yield advantage of intercropping as compared to monocropping[7]. The main subject of intercropping is to augment total productivity per unit area and time, besides judicious and equitable utilization of land resources and farming inputs including labours[8]. Intercropping could enhance total productivity of the system with low input investment by changing planting population and configuration. The greatest limitation of increasing the productivity of crops is inadequate supply of nutrients since most of the soils are poor in native fertility and continuous application of fertilizers even in imbalanced form may not sustain soil fertility and productivity. Thus, balanced fertilization along with sound crop husbandry offers a great scope for increasing productivity. Plant growth analysis is generally expressed as indices of growth such as Crop Growth Rate (CGR), Relative Growth Rate (RGR), Absolute Growth Rate (AGR), Net Assimilation Rate (NAR), leaf Area Ratio (LAR) and Leaf Area Index (LAI) [9]. In raised bed planted wheat, there is possibility of growing crops like spinach, fenugreek, oats fodder, canola and linseed in furrow. Increase in dry matter accumulation and physiological parameters can be achieved by growing appropriate component intercrop with the principal crop and balanced fertilizer application to the intercropping system.

2. Materials and Methods

The experiment was carried out during rabi seasons of 2012-13 and 2013-14 at the research farm of the Department of Agronomy, Punjab Agricultural University, Ludhiana. Soil of the experimental field was loamy sand with pH 7.2. It was moderately fertile being low in organic carbon (0.21%), available nitrogen (63.5 kg/ha), available potassium (122.19 kg/ha) and medium in available phosphorus (19.5 kg/ha). Sowing of wheat on beds was done with the help of a bed planter, which enables two wheat rows 20 cm apart on 37.5 cm wide bed and makes 30 cm wide furrow between two beds and intercrops were sown in consecutive furrows. Sowing time for the wheat variety PBW 621 and intercrops was 9 November 2012 and 12 November 2013. The recommended dose of N, P and K fertilizer was applied to wheat and intercrops on area basis as given in Table 1. The control of weeds on both beds and furrow was done by hand weeding. Other package of practices for wheat and intercrops were followed as per PAU recommendations. Wheat and intercrops were sown in 2:1 row arrangement. The experiment was laid out in a split-plot design with thee replications with five intercropping systems i.e. wheat + spinach, wheat + fenugreek, wheat + oats fodder, wheat + canola and wheat + linseed in the main plots. Each main plot was divided into four subplots to allocate the different levels of recommended dose of nutrients i.e. 0, 50, 75 and 100 % of recommended dose of nutrients to intercrops. The advantage of intercropping systems and different levels of recommended dose of nutrients to intercrops were evaluated using different physiological growth parameters. Weather data were recorded daily near the experimental site and are reported as mean monthly data for both the years (Figure-1).

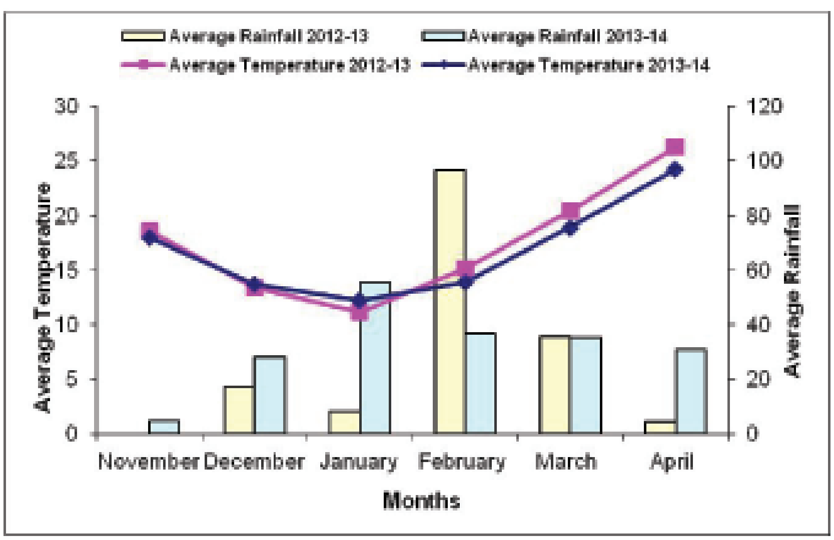

Figure 1. Meteorological parameters observed during crop growth period of 2012-13 and 2013-14.

Table1. Fertilizer requirements of different crops

Sr. No.	Crop	Recommended dose (kg/ha)		
		N	P_2O_5	K_2O
1	Wheat	125	62.5	30
2	Spinach	87.5	30	-
3	Fenugreek	12.5	20	-
4	Oats fodder	75	20	-
5	Canola	100	30	15
6	Linseed	62.5	40	-

The various growth indices were calculated as following:

Crop Growth Rate (CGR): It is the rate of growth per unit area and expressed as g/m^2 /day.

$$CGR = \frac{W2 - W1}{T2 - T1} X \frac{1}{P}$$

Where, W_1 and W_2 are dry weights of plants at times T_1 and T_2 respectively and P is land area

Relative Growth Rate (RGR): It indicates rate of growth per unit dry matter. It is expressed as g of dry matter produced by a g of existing dry matter in a day.

$$RGR = \frac{\log e\, W2\text{-}\log e\, W1}{T2 - T1}$$

Absolute Growth Rate (AGR): It indicates at what rate the crop is growing i.e. whether the crop is growing at a faster rate or slower rate than normal. It is expressed as g of dry matter produced per day.

$$AGR = \frac{W2 - W1}{T2 - T1}$$

3. Results and Discussion

3.1 Effect of Weather

In this research experiment, the meteorological data depicted in Figure 1 showed marked variation in weather conditions during the two years of experiment. Precipitation during the crop season in 2013-14 was 85.9 mm higher than during 2012-13. Consequently, to meet the water requirement of crops, more number of irrigations was applied during the first year than the second. Similarly, the average temperature during February to April coinciding with the reproductive and maturity stages of the wheat, canola and linseed crops remained milder during second year than the first. This elongates the growing periods of these crops during second year. This resulted in a slightly better performance of wheat, canola and linseed crop. But the performance of other short duration component crops such as spinach, fenugreek and oats fodder is declined in second year as compared to first year.

3.2 Effect on Dry Matter Accumulation

Crop growth analysis, one of the basic approaches to the analysis of yield influencing factors and plant development as net photosynthate accumulation is naturally integrated over time. Dry matter production and its accumulation are the best measures and index of the total performance and response of a crop[10]. In general the dry matter accumulation was very slow up to 60 days after sowing; thereafter it increased at a faster rate till physiological maturity, irrespective of treatments. Dry matter accumulation of wheat was not significantly influenced by the intercropping systems at 30 and 60 DAS. Among the intercropping systems highest values of dry matter accumulation of wheat was recorded in wheat + spinach intercropping system which was statistically at par with wheat + fenugreek, wheat + oats fodder and significantly higher than wheat + linseed and wheat + canola intercropping system at 90, 120 DAS and at maturity. Different levels of recommended dose of nutrients applied to intercrops did not significantly influence the dry matter accumulation of wheat at all the periodic interval (Table 2).

3.3 Effect on CGR and AGR

Crop dry matter production can be analyzed in terms of Crop Growth Rate (CGR) and relative growth rate (AGR), which are two important growth indices used in growth analysis[11]. Crop Growth Rate (CGR), the gain in weight of a community of plants on a unit of land in a unit time. It is regarded as the most common representative of growth function because it represents the net results of photosynthesis, respiration and canopy area interaction. Crop Growth Rates (CGR) and Absolute Growth Rate (AGR) are used extensively in growth analysis of field crops and these physiological parameters are best measure of the total performance of the crop[12]. Values from Table 3 and 4 showed that CGR and AGR were lowest during time interval 0-30 DAS, which was gradually increased up to 60-90 DAS time interval and after that declined. No effect

Table 2. Effect of different intercropping systems and levels of nutrients applied to intercrops on periodic dry matter accumulation (g/m^2) of wheat (pooled data of two years)

Treatments	Dry matter accumulation (g/m2)				
	30 DAS	60 DAS	90 DAS	120 DAS	At maturity
Intercropping systems					
Wheat + spinach	33.03	330.70	792.20	1081.31	1219.32
Wheat + fenugreek	32.47	324.33	785.82	1061.63	1197.82
Wheat + oats fodder	32.38	321.30	763.25	1031.48	1161.25
Wheat + canola	31.08	300.53	674.56	891.78	1000.12
Wheat + linseed	31.77	314.63	736.49	998.29	1124.49
CD (P=0.05)	NS	NS	42.59	58.80	66.15
% of recommended dose of nutrients to intercrops					
0	31.59	311.98	737.00	998.19	1125.96
50	31.87	315.15	745.64	1008.44	1136.45
75	32.45	321.81	755.19	1018.17	1146.40
100	32.66	324.26	764.03	1026.7	1153.58
CD (P=0.05)	NS	NS	NS	NS	NS

NS = Non- significant, DAS = Days after sowing

Table 3. Effect of different intercropping systems and levels of nutrients applied to intercrops on crop growth rate (g/m^2/ day) of wheat (pooled data of two years)

Treatments	crop growth rate (g/m^2/day)				
	0- 30 DAS	30-60 DAS	60-90 DAS	90-120 DAS	120- maturity DAS
Intercropping systems					
Wheat + spinach	1.10	9.92	15.38	9.64	4.60
Wheat + fenugreek	1.08	9.72	15.38	9.19	4.54
Wheat + oats fodder	1.08	9.63	14.73	8.94	4.32
Wheat + canola	1.04	8.98	12.47	7.24	3.61
Wheat + linseed	1.06	9.43	14.06	8.73	4.21
CD (P=0.05)	NS	NS	1.45	0.98	0.53
% of recommended dose of nutrients to intercrops					
0	1.05	9.35	14.17	8.71	4.26
50	1.06	9.44	14.35	8.76	4.26
75	1.08	9.65	14.44	8.77	4.27
100	1.09	9.72	14.66	8.77	4.28
CD (P=0.05)	NS	NS	NS	NS	NS

NS = Non- significant, DAS = Days after sowing

of intercropping systems on CGR and AGR was recorded at 0-30 and 30-60 DAS. Highest value of CGR of wheat was observed in wheat + spinach intercropping system which was statistically at par with the wheat + fenugreek, wheat + oats fodder and wheat + linseed intercropping system and significantly higher than the wheat + canola intercropping system, whereas, highest value of AGR was recorded in wheat + spinach intercropping system which was statistically at par with the wheat + fenugreek, wheat + oats fodder intercropping system and

Table 4. Effect of different intercropping systems and levels of nutrients applied to intercrops on absolute growth rate (g/meter row length/day) of wheat (pooled data of two years)

Treatments	Absolute growth rate (g/meter row length/ day)				
	0- 30 DAS	30-60 DAS	60-90 DAS	90-120 DAS	120- maturity DAS
Intercropping systems					
Wheat + spinach	0.37	3.35	5.19	3.25	1.55
Wheat + fenugreek	0.37	3.28	5.19	3.10	1.53
Wheat + oats fodder	0.37	3.25	4.97	3.02	1.46
Wheat + canola	0.35	3.03	4.21	2.45	1.22
Wheat + linseed	0.36	3.18	4.75	2.92	1.42
CD (P=0.05)	NS	NS	0.35	0.30	0.11
% of recommended dose of nutrients to intercrops					
0	0.36	3.15	4.78	2.94	1.44
50	0.36	3.19	4.84	2.96	1.44
75	0.37	3.26	4.88	2.96	1.44
100	0.37	3.28	4.95	2.97	1.45
CD (P=0.05)	NS	NS	NS	NS	NS

NS = Non-significant, DAS = Days after sowing

Table 5. Effect of different intercropping systems and levels of nutrients applied to intercrops on relative growth rate (g /g/day) of wheat (pooled data of two years)

Treatments	Relative growth rate (g /g/day)			
	30-60 DAS	60-90 DAS	90-120 DAS	120- maturity DAS
Intercropping systems				
Wheat + spinach	0.077	0.029	0.010	0.004
Wheat + fenugreek	0.077	0.029	0.010	0.004
Wheat + oats fodder	0.076	0.028	0.010	0.004
Wheat + canola	0.075	0.027	0.009	0.003
Wheat + linseed	0.076	0.028	0.010	0.004
CD (P=0.05)	NS	NS	NS	NS
% of recommended dose of nutrients to intercrops				
0	0.076	0.027	0.009	0.003
50	0.076	0.027	0.010	0.004
75	0.077	0.027	0.010	0.004
100	0.077	0.028	0.010	0.004
CD (P=0.05)	NS	NS	NS	NS

NS = Non-significant, DAS = Days after sowing

significantly higher than wheat + linseed and wheat + canola intercropping system at 60-90, 90-120 DAS and at 120-maturity. Significantly lowest values of dry matter accumulation, CGR and AGR were observed in wheat + canola intercropping system than the other intercropping system at all the periodic time intervals. It is because of canola is more aggressive, dominant and competitive to the wheat than rest of the intercrops, viz. spinach, fenugreek, oats fodder and linseed. All these intercrops possess different nature of growth, duration, plant habit, rooting pattern, canopy structure and days to maturity. Therefore, these crops differ in yield potential and possess differential competitive ability in intercropping systems. Intercropping of toria had a negative effect on the performance of wheat[13]. CGR and AGR of wheat did not significantly influence by different levels of recommended dose of nutrients applied to intercrops.

3.4 Effect on RGR

RGR in wheat was initially high and decreased with time and much of this decline would be attributed to an increase of self shading among canopy leaves[14] (Table 5). Different intercropping systems and levels of recommended dose of nutrients applied to intercrops did not significantly influence the RGR of wheat at all the periodic intervals. Higher value of dry matter accumulation and physiological growth parameters in wheat + spinach and wheat + fenugreek intercropping system was due to the less competitive ability of these crops to the wheat as compared to the canola, oats fodder and linseed in the intercropping system.

4. Conclusion

From the study, it was concluded that different levels of recommended dose of nutrients applied to intercrops did not significantly influence the dry matter accumulation and physiological growth parameters (CGR, AGR and RGR) of wheat. Among the intercropping systems, canola found to be more aggressive and competitive to wheat than the other component crops in intercropping system and significantly lowered the dry matter accumulation, CGR and AGR than the other intercropping systems.

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