Impact of different tillage practices and pre-mix herbicides on growth indices of wheat crop

Abstract

Growth indices changes from sowing till harvesting of the crop were monitored under the influence of four tillage options (Zero tillage no-residue, zero tillage with residue, conventional tillage no-residue and conventional tillage with residue) and four weed management practices (Sulfosulfuron + Metsulfuron @ (30+2) 32g a.i. ha^{-1}, Clodinafop propargyl + Metsulfuron methyl @ (60+4) 64 g a.i. ha^{-1}, Weed free (30 and 60 DAS) and weed check) during *rabi* season of 2019-20 and 2020-21. Analysis of the two years average data indicated that conventional tillage with residue along with application of clodinafop propargyl + Metsulfuron methyl @ (60+4) 64 g a.i. ha^{-1} resulted in the highest significant values of Crop Growth Rate (CGR) and Leaf Area Duration (LAD) upto 90 DAS after which it declines whereas Relative Growth Rate (AGR) show a declining trend from sowing till harvesting. Net Assimilation Rate (NAR) was found to be unaffected by the treatment during first year of experimentation. However, it was significantly affected during second year of experimentation which declines from sowing to harvesting. No interaction effect was found among different treatments. The overall findings concluded that conventional tillage with residue along with application of clodinafop propargyl + Metsulfuron methyl @ (60+4) 64 g a.i. ha^{-1} could be more beneficial in the study area.

Introduction

Wheat (*Triticum aestivum* L.) is the major crop of food supply in the region. Its importance may be understood from the fact that it exceeds all other crops in both area and production and major commodity in the world food trade and basic foodstuff of the developing countries (Hussain *et al.,* 2012). It is India's second most important cereal crop after rice (Pradhan *et al*., 2014), covering an area of 31.62 million ha with a production of 109.52 million tonnes and an average productivity of 3460 kg/ha in 2021-22 (Anonymous, 2022). The study estimates that India's overall demand for food grain will increase from 236.2 million tonnes in 2010 to 272-277 million tonnes in 2020 and 303-318 million tonnes in 2030 (Anonymous, 2022).It has an area of 223.40 million hectares with production of 778.60 million tones and the average productivity 3490 kg ha^{-1} at global level (Anonymous, 2022). Crop growth rate and relative growth rate are used extensively in growth analysis of field crops and these physiological parameters are best measure of the total performance of the crop (Nataraja *et al*., 2006). Besides these two other physiological parameters like leaf

area duration and net assimilation rate are also used. These growth parameters depend on various factors out of which two important factors are weed management and tillage options. It is weed which cause a heavy loss to wheat crop. The main reasons for its productivity are poor crop establishment and improper scheduling of irrigation. Ideal crop establishment is important for better and efficient utilization of plant growth resources and to get optimum productivity of wheat. It is also well-known fact that weed management is one of the major factors responsible for achieving better harvest in crop production. Farmers are always interested in getting higher yield which could not be possible without better crop management and optimum utilization of resources. Crop production is influenced by different tillage options like zero and conventional with and without residue and pre-mix herbicide herbicide combination which are the key factors towards crop development. Keeping in view these controversial statements, the present study was planned to investigate the crop growth indices of wheat in relation with different tillage options and weed management practices.

Method and Material

Two years field experiment entitled "Effect of tillage options, residue and weed management practices on productivity of wheat (*Triticum aestivum*L.)." were made on two factors at the Agronomy Research Farm of Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya (U.P.) during two successive *Rabi* seasons of 2019-20 and 2020-21. Ayodhya falls under subtropical climate having semi-arid to sub-humid areas and sometime subjected to extreme weather conditions *i.e.*, extremely hot summer and cold winters. Ayodhya is categorized under moisture deficit zone IV and the Moisture Deficit Index (MDI) ranges between -02 to -40. A field experiment consisted of split plot arrangement with three replications was carried out with two factors. Factor A contained four tillage options (Zero tillage no-residue, zero tillage with residue, conventional tillage no-residue and conventional tillage with residue) which were kept in main plots and factor B included four weed management practices (Sulfosulfuron + Metsulfuron @ (30+2) 32g a.i. ha^{-1}, Clodinafop propargyl + Metsulfuron methyl @ (60+4) 64 g a.i. ha^{-1}, Weed free (30 and 60 DAS) and weed check) were randomized in the sub plots. The soil of experimental field was moderate alkaline in reaction (pH) 8.32 and 8.26, low in organic carbon (0.31% and 0.32%), low in available nitrogen (189 kg ha^{-1} and 185 kg ha^{-1}), phosphorus (16.2 kg ha^{-1} and 16.3 kg ha^{-1}) and medium in potassium (282 kg ha^{-1} and 284 kg ha^{-1}) during 2019-20 and 2020-21, respectively. Various growth indices were calculated using the following formula given by the scientists.

Crop growth rate (g m^{-2} day^{-1})

The rate of dry matter production per unit land area per unit time or crop growth rate (CGR) was worked out by using the formula proposed by **Watson (1947)** and expressed as g m^{-2} day^{-1}.

$$CGR = \frac{W2 - W1}{t2 - t1} \times \frac{1}{P}$$

Where,

W_1 and W_2 are dry matter of crop (g) at time t_1 and t_2 respectively.

P= Ground area covered by crop (m^2)

Relative growth rate (g g^{-1} day^{-1})

The rate of increase in dry weight per unit dry weight of crop expressed in g g^{-1} day^{-1} was calculated using the formula suggested by **Blackman (1919).**

$$RGR = \frac{Log\ W2 - Log\ W1}{t2 - t1}$$

Where,

W_1 and W_2 are dry weight (g) of crop at time t_1 and t_2 respectively.

Net assimilation rate (g cm^{-2} day^{-1})

It indirectly indicates the rate of net photosynthesis. It is expressed as g of dry matter produced per m^2 of leaf area in a day. For calculating NAR, the total leaf area of crop has to be used but not the leaf area index. It was calculated at 30, 60 and 90 DAS intervals as per the formula given by **Beadle (1987)** and expressed in g cm^{-2} day^{-1}.

$$NAR = \frac{(W2 - W1)\ (Log\ LA2 - Log\ LA1)}{(t2 - t1)(LA2 - LA1)}$$

Where,

W_1 and W_2 are the dry matter accumulation (g) at time t_1 and t_2 respectively.

LA1 and LA2 are leaf area index at time t_1 and t_2 respectively.

Leaf Area Duration (day)

To correlate the dry matter yield with LAI, integrated the LAI with time and called as Leaf Area Duration. LAD takes account, both the duration and extent of photosynthetic tissue of the crop canopy. The LAD expresses in days.

$$\mathbf{LAD = (LA1 + LA2) \times (T2 - T1)/2}$$

Where,

LA1 = Leaf Area at time T_1

LA2 = Leaf Area at time T_2

The details of the procedures adopted for raising the crop and criteria used for treatment evaluation and methods adopted during the course of investigation are presented in this chapter.

Result and discussion

Crop growth rate (CGR) calculated from the different treatment showed significant variations at all growth stages except 30 DAS for both years. Conventional tillage with residue exhibited highest mean CGR except between 60-90 DAS where treatment failed to show any significant effect and it was at par with zero tillage with residue during both years. Zero tillage no-residue recorded lowest crop growth rate. Comparison of means in case of weed management treatment indicated that highest CGR lies with two had weeding (30 and 60 DAS). However, among herbicides, application of clodinafop +metsulfuron (60+4 g a.i. per ha at 30 DAS) recorded highest CGR which is at par with application of sulfosulfuron +metsulfuron (30+2 g a.i. per ha at 30 DAS). Minimum CGR was recorded in under weed check treatment. When compared the means two years it can be seen that CGR was highest during second year as compared to first year. It was also observed that after sowing, CGR increases from sowing to 90 DAS after which it declines. The CGR increased up to flowering thereafter it started declining, irrespective of treatments. It could be attributed to better soil aeration, less competition which favoured more root growth and photosynthetic activity . The reduction in crop growth rate at the time of harvesting is due to leaf senescence and decrease of leaf area index. This was supported by Sridevi and Chellamuthu(2015), Shekara *et al.*(2015).

In case of RGR different tillage practices failed to show any significant effect upto 60 DAS. Maximum mean RGR were recorded at early growth stages which decline till harvest. Highest RGR of wheat was obtained from conventional tillage with residue which is at par

with zero tillage with residue. However, the lowest RGR lies with the zero tillage no-residue. The means of the treatment after sowing for RGR showed (Table 1) that it increases in second year of experimentation as compare to first year. However, weed management practices also failed to show any significant effect at various growth stages. Among herbicidal treatment application of clodinafop +metsulfuron (60+4 g a.i. per ha at 30 DAS) recorded highest RGR followed by sulfosulfuron +metsulfuron (30+2 g a.i. per ha at 30 DAS). However, two hand weeding (30 and 60 DAS) recorded highest value of RGR. RGR was high in the early stages and it started declining progressively with the aging of the crop. The reason of declining in RGR at the final stage can be associated to increasing of the dead and woody tissues than the alive and active tissues and decrease of leaf area index. Similar result was given by Sridevi and Chellamuthu (2015).

Leaf area duration (RGR) calculated from the different treatment showed significant variations at all growth stages except 30-60 DAS of second year. Conventional tillage with residue exhibited highest LAD and it was at par with zero tillage with residue during both years. Zero tillage no-residue recorded lowest leaf area duration. Comparison of means in case of weed management treatment indicated that highest LAD lies with two had weeding (30 and 60 DAS). However, among herbicides, application of clodinafop +metsulfuron (60+4 g a.i. per ha at 30 DAS) recorded highest LAD which is at par with application of sulfosulfuron +metsulfuron (30+2 g a.i. per ha at 30 DAS). Minimum LAD was recorded in under weed check treatment. When compared the means two years it can be seen that LAD was highest during second year as compared to first year. It was also observed that after sowing, LAD increases from sowing to 90 DAS. LAD increased with the age of the crop, with maximum LAD at flowering stage. LAD expresses the magnitude and persistence of leaf area of leafiness during the period of crop growth. It reflects the extent or seasonal integral of light interception and correlates with yield. The closely findings are Sridevi and Deepika *et al.*(2017).

In case of NAR different treatment failed to show any significant effect at various growth stages during first year of experimentation. However, a significant variation was recorded during second year at various growth stages. Maximum NAR were recorded at early growth stages which decline further. Highest NAR of wheat was obtained from conventional tillage no-residue which is at par with zero tillage no-residue. However, the lowest NAR lies with the conventional tillage with residue. The means of the treatment after sowing for NAR showed that it increases in second year of experimentation as compare to first year.

However, among herbicidal treatment application of sulfosulfuron +metsulfuron (30+2 g a.i. per ha at 30 DAS) clodinafop +metsulfuron (60+4 g a.i. per ha at 30 DAS) recorded highest NAR. However, two hand weeding (30 and 60 DAS) recorded lowest value of NAR and weed check the highest one. NAR was high in the early stages between active tillering and panicle initiation and thereafter the rate of increase was slow with advancement in the age of the crop. Reduction in NAR could be attributed to less leaf area and shortage of other growth factors like nutrient, space, water etc. The closely findings are Sridevi and Chellamuthu (2015).

Conclusion

If we summarize the overall results of this study, it can be concluded that conventional tillage with residue in combination with clodinafop +metsulfuron (60+4 g a.i. per ha at 30 DAS) accelerated the growth indices hence growth of the crop.

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Table 1: Effect of tillage options, residue and weed management practices on relative growth rate (g g^{-1} day^{-1}) × 10^{-3}

Treatments	0-30 DAS		30-60 DAS		60-90 DAS		90 DAS-- Harvest	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Tillage options								
Zero tillage no-residue	113.14	113.70	73.10	72.84	34.81	34.77	9.19	9.15
Zero tillage with residue	112.82	113.35	75.09	74.86	33.75	33.74	9.58	9.58
Conventional tillage with residue	113.58	114.53	75.28	74.76	33.00	32.86	9.51	9.65
Conventional tillage no-residue	113.35	113.53	73.77	73.71	34.16	34.18	9.54	9.59
SEm±	0.71	0.63	0.55	0.44	0.24	0.25	0.07	0.08
CD at 5%	NA	NA	NA	NA	0.87	0.90	0.27	0.31
Weed management								
Sulfosulfuron +metsulfuron (30+2 g a.i. per ha	113.26	113.79	74.30	73.99	34.04	34.07	9.54	9.59
Clodinafop +metsulfuron (60+4 g a.i. per ha	113.61	114.16	74.10	73.82	33.92	33.91	9.56	9.58
Two hand weeding (30 & 60 DAS)	113.90	114.58	74.38	74.01	33.58	33.54	9.43	9.47
Weed check	112.12	112.63	74.47	74.36	34.19	34.02	9.29	9.33
SEm±	0.70	0.72	0.49	0.56	0.24	0.28	0.06	0.07
CD at 5%	NA	NA	NA	NA	NA	NA	NA	NA

Table 2: Effect of tillage options, residue and weed management practices leaf area duration (Days)

Treatments	30 DAS- 60 DAS		60 DAS- 90 DAS	
	2019-20	2020-21	2019-20	2020-21
Tillage options				
Zero tillage no-residue	49.55	50.22	65.58	64.95
Zero tillage with residue	51.57	51.56	68.66	68.91
Conventional tillage with residue	52.13	52.45	70.32	70.28
Conventional tillage no-residue	49.85	50.71	66.12	67.02
SEm±	0.30	0.55	0.34	0.55
CD at 5%	1.06	NA	1.21	1.95
Weed management				
Sulfosulfuron +metsulfuron (30+2 g a.i. per ha	50.67	51.18	67.17	67.70
Clodinafop +metsulfuron (60+4 g a.i. per ha	51.45	51.48	68.95	68.82
Two hand weeding (30 & 60 DAS)	51.78	52.75	69.78	69.47
Weed check	49.20	49.52	64.78	65.17
SEm±	0.39	0.41	0.54	0.48
CD at 5%	1.15	1.20	1.60	1.42

Treatments	0-30DAS		30-60 DAS		60-90 DAS		90DAS -Harvest	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Tillage options								
Zero tillage no-residue	0.99	1.01	7.91	7.97	16.29	16.39	8.04	8.06
Zero tillage with residue	0.98	1.00	8.37	8.44	16.39	16.51	8.56	8.66
Conventional tillage with residue	1.00	1.03	8.63	8.72	16.40	16.53	8.58	8.78
Conventional tillage no-residue	1.00	1.00	8.14	8.18	16.33	16.42	8.44	8.50
SEm±	0.01	0.01	0.06	0.07	0.057	0.07	0.07	0.07
CD at 5%	NA	NA	0.23	0.24	NA	NA	0.25	0.27
Weed management								
Sulfosulfuron +metsulfuron (30+2 g a.i. per ha	0.99	1.01	8.27	8.31	16.43	16.55	8.48	8.59
Clodinafop +metsulfuron (60+4 g a.i. per ha	1.00	1.02	8.30	8.36	16.44	16.57	8.52	8.64
Two hand weeding (30 & 60 DAS)	1.01	1.03	8.45	8.52	16.45	16.57	8.55	8.64
Weed check	0.96	0.98	8.03	8.13	16.09	16.15	8.07	8.16
SEm±	0.02	0.02	0.08	0.08	0.06	0.11	0.05	0.06
CD at 5%	NA	NA	0.25	0.25	0.17	0.34	0.16	0.17

Table 3: Effect of tillage options, residue and weed management practices on crop growth rate (g/m^2/ day)× 10^{-3}

Table 4: Effect of tillage options, residue and weed management practices on net assimilation rate (g/m^2/ day)× 10^{-3}

	30 DAS- 60 DAS		60 DAS- 90 DAS	
Treatments	**2019-20**	2020-21	2019-20	2020-21
Tillage options	28.36	35.19	28.25	35.13
Zero tillage no-residue	29.15	33.81	29.10	34.02
Zero tillage with residue	29.41	32.96	29.29	32.56
Conventional tillage with residue	29.98	36.37	29.82	36.45
Conventional tillage no-residue	0.54	0.49	0.60	0.67
SEm±	NS	1.42	NS	1.96
CD at 5%				
Weed management	30.45	36.29	30.16	36.25
Sulfosulfuron +metsulfuron (30+2 g a.i. per ha	28.94	34.18	28.75	34.03
Clodinafop +metsulfuron (60+4 g a.i. per ha	28.55	32.81	28.67	33.12
Two hand weeding (30 & 60 DAS)	28.96	34.79	28.86	34.77
Weed check	0.54	0.47	0.59	0.65
SEm±	NS	1.39	NS	1.93
CD at 5%				