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Effect of seed rate and weed management practices on growth parameters and dry matter accumulation of late sown wheat (*Triticum aestivum* L.)

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Abstract
An experiment was conducted at Crop Research Center of Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh during Rabi seasons of 2012-13 and 2013-14 to assess the effect of seed rate and weed management practices on growth parameters and dry matter accumulation of late sown wheat (*Triticum aestivum* L.). The treatment consisted of three seed rate 100,125 and 150kg ha^{-1} in main plot and six weed management practices viz. Sulfosulfuron 25 g ha^{-1}, Sulfosulfuron + Metsulfuron (30 + 2 g ha^{-1}), Clodinafop + Metsulfuron (60 + 4 g ha^{-1}), Fenoxaprop-p-ethyl + Metribuzin (120 + 210 g ha^{-1}), two hand weeding (120 and 40 DAS) and weedy check in sub-plots. The experiment was laid out in split plot design with three replications. Sowing with 150 kg ha^{-1} seed rate recorded maximum germination count at 15 DAS, number of tillers/m^{1} row length, Plant height, leaf area index (LAI), and dry matter accumulation which were significantly higher than 100 and 125 kg ha^{-1} seed rate. Germination count of wheat at 15 DAS was almost similar under all the weed management practices. At 30 DAS two hand weeding produce significantly higher number of tillers m^{-1} row length and plant height than rest of the weed management practices, while LAI and dry matter accumulation was non-significant. At 60, 90 DAS and at harvest number of tillers, Plant height, LAI and dry matter accumulation recorded maximum with two hand weeding which was at par with Clodinafop + Metsulfuron (60 + 4 g ha^{-1}), Sulfosulfuron + Metsulfuron (30 + 2 g ha^{-1}), Sulfosulfuron 25 g ha^{-1} and significantly higher than Fenoxaprop-p-ethyl + Metribuzin (120 + 210 g ha^{-1}) and weedy check. Fenoxaprop-p-ethyl + Metribuzin (120 + 210 g ha^{-1}) had Phytotoxic effect on wheat plants was produce minimum number of tillers, plant height, leaf area index and dry matter accumulation at all the stages of observation taken which was at par with weedy check.

Keywords: seed rate, herbicide, LAI, growth character's and Dry weight

Introduction
Wheat is an important prime cereal crop among the food-grain is grown in an area of 29.65 m ha in India, with the production 93.5 million tonnes and average productivity 31.53 q ha^{-1} (FAO, 2013) [4]. Among several causes of low productivity in Uttar Pradesh, adoption of rice-wheat rotation is one. Late transplanting of rice or use of long duration varieties in low land fields delays the sowing of wheat. The preceding crop like sugarcane, potato, paddy and toria etc. vacate the field late in season after normal sowing date of wheat and other factors enforce the crop be sown as much late as in the end of December and beginning of January. Late sown crop experiences high temperature, declining relative humidity and hot dissecting winds in later stage of crop growth, particularly during grain filling stage. Yield potential and productivity of wheat under late sown condition is poor due to less exploitation of potentialities of the crop. Emergence of seedling due to low temperature curtailing the periods from emergence to maturity in late sown condition optimum plant population can be maintain by optimum seed rate (Singh and Singh, 1987) [17]. Late sowing of wheat tends to reduce germination count due to low temperature at germination and tillers unit^{-1} area because of rise in temperature during tillering phase of the crop and consequently increase in the temperature at milking stage of the crop is the major threat affecting the productivity adversely. To mitigate the deleterious effect of delayed sowing, increasing seed rate will be a viable and economic option to compensate the reduction germination count and number of tillers per unit area. Seed

rate plays a vital role for optimum plant densities which is a pre-requisite for increased seed yield, it influences the yield and yield attributes of wheat (Singh and Singh, 1987) [17]. Higher seed rate produces more plants in unit area resulting the higher yield and production cost, on the other hand, lower seed rate may reduce the yield drastically. A high seed rate is required to secure an optimum and effective plant population for better yield and it is also expected to reduce weed growth, weed density and dry matter are supposed to be suppressed substantially through increasing plant populations (Zindahl, 1999) [19]. Thus variation in seed rate and weed control method instruct to influence growth and yield of wheat. Khan *et al.* (2002) [7] reported that 150 kg seed rate/ha had higher emergence (56.0 plant $m.^{-2}$), number of tillers (264.37 m^2), and plant height (88.25cm). Duary *et al*. (2006) reported that increase in seed rate from 100 to 150 kg/ha enhanced the dry matter production of wheat by 10.4 and 16.9% at 60 DAS and 3.7 and 7.7% at 90 DAS. Total number of tillers per square metre increased with the increase in seed rate.

Weeds are also considered as major constraints in wheat cultivation under late sown condition. Increasing population of canary grass (*Phalaris minor retz*.) with broad leaf weeds causing substantial yield loss in rice-wheat cropping system, yield reduction due to weeds is 38-42% (Bharat and Kachroo, 2007) [1] or even more. Due to severe infestation of *Phalaris minor* significant reduction in wheat yield ranging from 18-73% has been reported by Pal *et al*. (2012) [12] reported that significant effect of weed control measures on crop growth parameters like plant height, tillers number and crop dry matter accumulation at all the stages of observation then weedy check. Keeping these facts in view, the present investigation was under taken to study the effect of seed rate and weed management practices on growth parameters and dry matter accumulation of late sown wheat (*Triticum aestivum* L.)

Materials and Methods

A field experiment was conducted during Rabi seasons of 2012-13 and 2013-14 at Crop Research Center of Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, belong to North Western Plain Zone in irrigated ecosystem. Soil was sandy loam in texture having pH 7.81 and 8.21, organic carbon 0.43-0.41% and available NPK was 178.6 and 175; 17.4 and 16.5; 25.5 and 250.4 kg ha^{-1} during 2012-13 and 2013-14, respectively. The treatment comprised of three seed rates (100, 125 and 150 kg ha^{-1}) in main- plots and five weed management practices, *viz*. Sulfosulfuron 25 g ha^{-1}, Sulfosulfuron + Metsulfuron (30 + 2 g ha^{-1}), Clodinafop + Metsulfuron (60 + 4 g ha^{-1}), Fenoxaprop-p-ethyl + Metribuzin (120 + 210 g ha^{-1}), two hand weeding (120 and 40 DAS) and weedy check in sub-plots. The experiment was laid out in split plot design with three replications. A promising wheat variety PBW-590 recommended for late sown condition for NWPZ of wheat was sown on 08 and 09 December during 2012-13 and 2013-14, respectively. A uniform dose of 120 kg N, 60 kg P and 40 kg K ha^{-1} was applied in the form of Urea, Di-ammonium phosphate and Muriate of potash in all the plots. One-third dose of nitrogen and full dose of phosphorus and potassium were applied as basal and remaining two-thirds of nitrogen was applied through urea as top dressing after first irrigation and panicle initiation stages. First irrigation was given at crown root initial stage after that crop was irrigated 20-25 days interval to avoid any kind of water stress. Herbicides were applied as post emergence *i.e*. 30 DAS with the help of hand-operated Knapsack sprayer, fitted with flat fan nozzle with 250 litter ha^{-1}water. First hand weeding was done at 20 and second at 40 DAS. Germination count was recorded at 15 DAS, LAI at 30, 60 and 90 DAS, number of tillers, plant height and dry matter accumulation are recorded at 30, 60, 90 and at harvest.

Results and Discussion

Germination count at 15 DAS

Initial plant population influenced significantly by the varying seed rates. The highest number of plants m^{-1} row length was noted under the use of 150 kg ha^{-1} seed rate over lower seed rates of 100 and 125 kg ha^{-1} has also been reported by Khan *et al.*, 2002 [7]; Malik *et al.*, 2009 [11] and Iqbal *et al.*, 2012 [15]. The initial plant population per unit area was not influenced appreciably by the different weed management practices.

No. of tillers m^{-1} row length

The effect of seed rate on no. of tillers m^{-1} row length was significantly higher with 150 kg ha^{-1} seed rate over 100 and 125 kg ha^{-1} seed rate at all stages of crop growth during both years of experiment (Table1). Similar results reported by Khan *et al.*, 2002 [7] and Malik *et al.*, 2009 [11]. Weed management practices did not have significant effect on number of tillers at 30 DAS, but at 60 and 90 DAS no. of tillers significantly affected by the different weed management practices. Two hand weeding produce maximum no. of tillers was at par with Clodinafop + metsulfuron (60 + 4 g ha^{-1}) at all stages than rest of the weed management practices. Herbicide Clodinafop + metsulfuron (60 + 4 g ha^{-1}) produce significantly higher no. of tillers at 60, 90 DAS and at harvest stage was at par with sulfosulfuron + metsulfuron (30 + 2 g ha^{-1}) and sulfosulfuron 25 g ha^{-1}. This might be due to smothering effect. These results are in conformity with findings of Punia *et al*. (2008) [14], Singh *et al*. (2012) [18]; Kumari *et al.* (2013) [9]. Minimum no. of tillers m^{-1} recorded with fenoxaprop-p-ethyl + metribuzin (120 + 210 g ha^{-1}). This might be due to phytotoxic effect on wheat plant. Similar results were reported by Bhullar *et al*. (2012) [2] and Shehzad *et al.* (2012) [16].

Plant height

The varying seed rates had significant effect on plant height at all the stages of crop growth *viz*., 30, 60, 90 DAS and at harvest during both years (Table 2). Seed rate 150 kg ha^{-1} recorded taller plant height than 100 and 125 kg ha^{-1} seed rate. It is clear that taller plants were recorded at higher seed rate (150 kg ha^{-1}) might be due to more competition for space and light cause of increased plant population per unit area. Panwar *et al.*, 1989 [13]; Mahajan *et al.*, 1991 [10]; Khan *et al.*, 2002 [7]; Kabir *et al.*, 2009 [6] have also reported that higher seed rate of 150 kg ha^{-1} recorded taller plant than 100 and 125 kg ha^{-1} seed rate. Weed management practices had significant effect on plant height at 90 DAS and at harvest while non-significant at 30 and 60 during both years. Maximum plant height recorded with two hand weeding was at par with Clodinafop + metsulfuron (60 + 4 g ha^{-1}) it might be due to effective weed control resulting more plant population per unit area therefore more competition for light and space resulting higher plant height. Fenoxaprop-p-ethyl + metribuzin (120 + 210 g ha^{-1}) recorded shortest plants due to its phytotoxic effect on plants. Almost some results recorded by Bhullar *et al.* (2012) [2], Shazad *et al.* (2012).

Leaf area index

Leaf area directly responsible to synthesis and store more food material through the process of photosynthesis, seed rate had significant effect on leaf area index (Table3). Maximum leaf area index recorded with 150 kg ha^{-1} seed rate was significantly higher than 100 and 125 kg ha^{-1} seed rate while at par with 125 kg ha^{-1} at 90 DAS during both years. This might be due to more plant population and leaves per unit area. Leaf area index increase up to 60 DAS thereafter decrease in LAI. During later stages because of the leaves senescence photosynthesis decreased drastically and as consequences increase in height and number of tillers recorded. Weed management practices had significant effect on leaf area index at 60 and 90 DAS while no significant affect at 30 DAS. Two hand weeding recorded significantly higher LAI at 60 and 90 DAS was at par with Clodinafop + metsulfuron (60 + 4 g ha^{-1}), Sulfosulfuron + metsulfuron (30 + 2 g ha^{-1}) and Sulfosulfuron 25 g ha^{-1} but significantly higher than fenoxaprop-p-ethyl + metribuzin (120 + 210 g ha^{-1}) and weedy check. Due to its phytotoxic effect fenoxaprop-p-ethyl + metribuzin (120 + 210 g ha^{-1}) recorded minimum leaf area index was at par with weedy check.

Dry matter accumulation

Seed rate and weed management practices had significant effect on dry matter accumulation at all stages of crop growth during both years (Table 4). Higher seed rate of 150 kg ha^{-1} produce maximum dry matter than its lower levels of 125 and 100 kg ha^{-1} seed rate. Almost same results were obtained by Kublar and Khaut (1982). Weed management practices had significant effect on dry matter accumulation at 60, 90 and at harvest whereas at 30 DAS non-significant effect recorded during both years. Two hand produce maximum dry matter was at par with Clodinafop-p-ethyl (60 + 4 g ha^{-1}), Sulfosulfuron + metsulfuron (30 + 2 g ha^{-1}) and Sulfosulfuron 25 g ha^{-1} at 60 DAS while 90 DAS and at harvest at par with Clodinofop + metsulfuron (60 + 4 g ha^{-1}) and Sulfosulfuron + metsulfuron (30 + 2 g ha^{-1}) and significantly superior than rest of the rest of the weed management practices. This might be due to effective weed control by such treatments. Herbicide Clodinafop + metsulfuron (60 + 4 g ha^{-1}) produce more dry weight at par with sulfosulfuron + metsulfuron (30 + 2 g ha^{-1}) and significantly higher than rest of the treatments. Due to its phytotoxic effect on plant fenoxaprop-p-ethyl + Metribuzin (120+210 g ha^{-1}) produce minimum dry weight was equal to weedy check. Almost same finding reported by Singh *et al*. (1987) [17], Bibi *et al*. (2008), Pal *et al*. (2012) [12] and Saquib *et al.* (2012) [15].

Summary and Conclusion

Maximum Germination count, plant height, number of tillers, leaf area index and dry matter accumulation were recorded at 150 kg ha^{-1} seed rate which was significantly higher than 100 and 125 kg ha^{-1} seed rate. Germination count of wheat at 15 DAS was almost similar under all the weed management practices during both years. Two hand weeding recorded maximum number of tillers m^{-1} row length, plant height, leaf area index and dry matter accumulation which was at par with Clodinafop + metsulfuron (60 + 4 g ha^{-1}), Sulfosulfuron + metsulfuron (30 + 2 g ha^{-1}). And Sulfosulfuron 25 g ha^{-1} at all stages of crop growth but significantly higher than Fenoxaprop-p-ethyl + metribuzin (120 + 210 g ha^{-1}) and weedy check. Fenoxaprop-p-ethyl + Metribuzin (120+210) had phytotoxic effect on wheat plants was produce minimum number of tillers, plant height, leaf area index and dry matter accumulation, was at par with weedy check during both years. It had been concluded that sowing with 150 kg ha^{-1} seed rate and application of herbicide Clodinafop + Metsulfuron (60 + 4 g ha^{-1})or Sulfosulfuron + metsulfuron (30 + 2 g ha^{-1}) found better for all growth parameters of wheat.

Table 1: Effect of seed rate and weed management practices on germination count and number of tillers m^{-1} row length of wheat

Treatment	Germination at 15 DAS		30 DAS		60 DAS		90 DAS		At harvest	
	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14
Seed rate										
100 Kg ha^{-1}	37.83	37.00	62.17	60.67	90.89	89.78	86.44	86.00	79.89	75.61
125 Kg ha^{-1}	47.50	46.67	71.39	68.67	105.56	104.50	100.89	100.94	81.44	79.00
150 Kg ha^{-1}	55.67	57.17	73.00	72.33	110.56	108.83	105.78	105.89	85.56	83.94
SEm(±)	0.63	0.75	0.93	0.93	1.10	1.10	0.84	0.82	0.82	0.79
C.D. (P=0.05)	2.54	3.03	3.73	3.75	4.43	4.45	3.38	3.31	3.32	3.20
Weed management practices										
Sulfosulfuron@ (25 g ha^{-1})	49.00	47.67	68.78	67.33	106.78	103.67	101.56	99.11	81.67	79.67
Sulfosulfuron+ Metsulfuron @ 30 g + 2 g ha^{-1}	48.00	47.33	68.00	66.00	110.22	108.22	104.56	104.00	84.33	82.11
Clodinafop+ Metsulfuron @ 60 g + 4 g ha^{-1}	44.67	46.33	67.00	65.67	111.67	109.89	106.56	105.00	85.33	83.22
Fenoxaprop+ Metribuzin @120 g + 210 g ha^{-1}	47.33	46.67	68.67	66.67	81.11	81.89	78.67	81.00	75.00	71.22
Two hand weeding (20 & 40 DAS)	45.67	46.33	72.33	70.33	112.56	110.44	107.22	106.67	85.67	83.67
Weedy Check	48.33	47.33	68.33	67.33	91.67	92.11	87.67	89.89	75.78	72.22
SEm(±)	2.47	2.47	2.83	3.31	3.43	3.65	2.64	3.10	2.44	2.50
C.D. (P=0.05)	NS	NS	NS	NS	9.95	10.60	7.66	9.00	7.08	7.26

Table2: Plant height (cm) of wheat as influenced by seed rate and weed management practices

Treatment	30DAS		60DAS		90DAS		At harvest	
	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14
Seed rate								
100 Kg ha^{-1}	18.68	18.39	41.96	41.61	75.63	75.28	80.92	80.69
125 Kg ha^{-1}	19.61	19.39	42.99	42.73	77.06	76.82	82.48	82.27
150 Kg ha^{-1}	20.30	19.77	44.01	43.81	78.70	78.74	84.18	83.62
SEm(±)	0.20	0.21	0.40	0.33	0.46	0.46	0.46	0.46
C.D. (P=0.05)	0.81	0.86	1.60	1.32	1.85	1.83	1.84	1.87
Weed management practices								
Sulfosulfuron@ (25 g ha^{-1})	19.43	19.08	43.36	42.71	77.53	76.86	83.49	83.01

Sulfosulfuron+Metsulfuron @ 30g + 2 g ha^{-1}	19.40	19.06	43.31	43.32	78.43	78.08	84.04	83.59
Clodinafop+ Metsulfuron @ 60 g + 4 g ha^{-1}	19.49	19.13	43.47	43.45	78.52	78.27	84.14	83.68
Fenoxaprop+ Metribuzin @120 g + 210 g ha^{-1}	19.34	18.95	41.14	40.76	73.60	73.58	76.91	76.81
Two hand weeding (20 & 40 DAS)	20.18	19.96	43.82	43.70	78.59	78.38	84.21	83.74
Weedy Check	19.33	18.94	42.81	42.35	76.11	76.51	82.38	82.33
SEm(±)	0.75	0.72	1.21	1.08	1.44	1.41	1.41	1.44
C.D. (P=0.05)	NS	NS	NS	NS	4.18	4.09	4.11	4.19

Table 3: Effect of seed rate and weed management practices on leaf area index of wheat

Treatment	30 DAS		60 DAS		90 DAS	
	2012-13	2013-14	2012-13	2012-13	2012-13	2013-14
Seed rate						
100 Kg ha^{-1}	1.62	1.58	4.04	3.99	3.48	3.44
125 Kg ha^{-1}	1.67	1.63	4.18	4.15	3.62	3.57
150 Kg ha^{-1}	1.87	1.83	4.39	4.37	3.77	3.70
SEm(±)	0.03	0.03	0.03	0.04	0.06	0.03
C.D. (P=0.05)	0.13	0.14	0.13	0.15	0.25	0.13
Weed management practices						
Sulfosulfuron@ 25 g ha^{-1}	1.70	1.65	4.39	4.34	3.74	3.67
Sulfosulfuron+ Metsulfuron @ 30 g + 2 g ha^{-1}	1.72	1.67	4.40	4.39	3.77	3.74
Clodinafop+ Metsulfuron @ 60 g + 4 g ha^{-1}	1.73	1.69	4.42	4.41	3.80	3.76
Fenoxaprop+ Metribuzin @120 g + 210 g ha^{-1}	1.69	1.67	3.78	3.71	3.40	3.26
Two hand weeding (20 & 40 DAS)	1.80	1.77	4.43	4.42	3.81	3.76
Weedy Check	1.69	1.65	3.82	3.76	3.34	3.25
SEm(±)	0.11	0.14	0.11	0.11	0.31	0.12
C.D. (P=0.05)	NS	NS	0.32	0.33	0.38	0.36

Table 4: Dry matter accumulation (g) of wheat per running meter row length as influenced by seed rate and weed management practices

Treatment	30 DAS		60 DAS		90 DAS		At harvest	
	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14
Seed rate								
100 Kg ha^{-1}	12.57	12.43	80.62	78.58	176.32	173.91	263.99	261.89
125 Kg ha^{-1}	14.34	13.86	81.62	80.64	181.20	179.91	270.52	268.96
150 Kg ha^{-1}	15.90	15.39	83.44	82.35	186.52	184.42	277.48	275.89
SEm(±)	0.22	0.27	0.21	0.58	0.55	0.64	0.71	0.67
C.D. (P=0.05)	0.87	1.10	0.83	2.32	2.22	2.56	2.88	2.68
Weed management practices								
Sulfosulfuron@ 25 g ha^{-1}	14.12	13.73	83.62	82.44	182.23	179.73	270.55	269.21
Sulfosulfuron+ Metsulfuron @ 30 g + 2 g ha^{-1}	14.22	13.74	84.11	83.04	191.22	189.19	282.61	280.96
Clodinafop+ Metsulfuron @ 60g + 4 g ha^{-1}	14.28	13.76	84.42	83.10	191.71	189.48	283.62	281.30
Fenoxaprop+ Metribuzin @120 g + 210 g ha^{-1}	14.17	14.10	76.50	75.22	163.92	161.61	249.12	248.14
Two hand weeding (20 & 40 DAS)	14.68	14.31	84.13	83.11	191.95	189.56	284.93	281.54
Weedy Check	14.15	13.73	77.57	76.24	167.06	166.89	253.14	252.33
SEm(±)	0.72	0.69	1.16	1.43	1.81	1.94	2.17	2.20
C.D. (P=0.05)	NS	NS	3.37	4.16	5.24	5.63	6.30	6.38

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