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Vikas Tomar
Department of Agronomy C S Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

Narinder Panotra
Directorate of Research, Sher-e-Kashmir University of Agricultural Sciences & Technology of Jammu, Jammu and Kashmir, India

Ravindra Tomer
Department of Agronomy C S Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

Gautam Singh Dhaked
Department of Agronomy FOA&VS, Mewar University, Chittorgarh, Rajasthan, India

Corresponding Author:
Vikas Tomar
Department of Agronomy C S Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

Effect of different herbicides and planting techniques on yield and yield components of in late sown wheat (*Triticum aestivum* L.)

Vikas Tomar, Narinder Panotra, Ravindra Tomer and Gautam Singh Dhaked

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Abstract
An experiment was conducted at C S Azad University of Agriculture and Technology, Kanpur District of Uttar Pradesh during *rabi* seasons of 2015-16 and 2016-17 to find out the effect of different herbicides and planting techniques on yield and yield components of in late sown wheat (*Triticum aestivum* L.). The treatments consisted three planting techniques and five weed management practices. The experiment was laid out in split plot design with three replications. Planting method plays an important role in the placement of seed at proper depth, which ultimately affects crop growth. The selection of suitable planting method for wheat is dependent upon the time of planting, availability of soil water at planting time, amount of residue in the field. The results showed that plant height was increasing with increasing days after sowing in the relevant crop of wheat, respectively. The tallest plants were obtained in Cross sowing followed by Line sowing. The application of weed management practices on Two hand weeding (25 and 45 DAS) and Clodinofop (60g ha^{-1}) fb 2,4-D (500 g ha^{-1}), significantly improved the yield and yield components of Two hand weeding (25 and 45 DAS) followed by Clodinofop (60g ha^{-1}) fb 2,4-D (500 g ha^{-1}), amongst different treatments during both year.

Keywords: Sowing methods, weed management practices, Plant height, yield, Harvest index, B:C ratio

Introduction
Wheat is the backbone of food security of India. It is utilized for bread, cakes, cookies, noodles, petri-products and chapatti etc. Wheat grains contains starch 60-68%, protein 8-15%, fat 1.5-2.0%, cellulose 2.0-2.5%, and minerals 1.5-2.0% (Rathore, 2001) [6]. Wheat is the second most important cereal crop next to rice and accounts for 36.2% of total food grain basket of the country. It is grown under diverse agro climatic conditions. The total area of wheat in the world is 221.12 million hectare with annual production of 697.8 million tonnes and productivity of 31.55 q ha^{-1}. The largest producer of wheat in the world is the European Union followed by China, India and United States of America. The consumption of wheat in the world is 667 million tonnes but is kept satisfied with an equally high production figures. Consumption has been constantly increasing during the last 15 years with the increase in population and is prepared to shoot up further to 780 million tonnes in 2020. It has been estimated that India will need at least 109 million tonnes of wheat by 2020 as against present production of 93.5 million tonnes. The wheat production has increased manifold from 6.60 million tonnes at the time of independence to 97.44 million tons (Anonymous, 2017) [1].
The productivity has witnessed an increase by 473 per cent *i.e.* from 670 kg ha^{-1} to 3172 kg ha^{-1} during the above period. Despite delayed sowing, the country recorded 30.71 million hectares. The clearly indicates the strength of systematic and planned wheat research in the country. It may be recalled that the total wheat production of the country during 1947-48 was just 5.6 million tons with average productivity of less than one t ha^{-1}. India has witnessed a record yield breaking increase in total wheat production *i.e.* 93.50 million tons from an area of 30.60 m ha^{-1} with the productivity of 30.93 q ha^{-1} during 2015-16. Out of total area of wheat in India, Uttar Pradesh alone contributes area 9.65 million hectare and production near about 26.87 million tons with productivity of 27.72 q ha^{-1}. Wheat consumption in India estimated to surpass 110 million tons of wheat will be needed by 2020. Late sown crop experiences high temperature, declining relative humidity and hot dissecting winds in later stage of crop growth, particularly during grain filling stage. Exposure of crop to abnormally high temperature, desiccating winds and low relative humidity results in sever set back to grain filling and consequently the yields.

Under such a situation, higher seed rate may affect the micro-environment and growth pattern of individual crop plant, leading to an overall increase in yield. 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).

Wheat crop contributes substantially to the national food security by providing more than 50% of the calories to the people who mainly depend on it. The effects of weeds on wheat crop, the impact of weed competition on quantity and quality of wheat yield, allelopathic effects of certain weeds on crop growth and development and the poison effect of other weed species to humans and animals. Weeds usually found in wheat fields and associate with crop plants were identified and grouped based on their morphology. Studies on the determination of the critical weed-free period in wheat were reviewed and the importance of this period in weed management was discussed. Chemical and none-chemical weed control methods were reviewed. Certain agricultural and management practices aimed at promoting early canopy crop development and reduce weed growth are mentioned. Importance of plant factors, timing of farm operations, and selection of proper herbicide are discussed. Most recent research findings on weed management in wheat fields are incorporated. Herbicides recommended and practiced in wheat, their type, method of action, method and time of application, physiological effects on crop plants and weeds, and recent research findings on this aspect were included. Some suggestions and recommendations that sustain weed management and aimed at increasing crop productivity and minimizing weed effects are discussed Sharma & Saroa, 2017 [5].

Materials and Methods

The study was conducted at C S Azad University of Agriculture and Technology, Kanpur in alluvial tract of gangatic plains in Central part of Uttar Pradesh during *rabi* seasons of 2014-15 and 2015-16. The soil of the experimental field was sandy loam in texture and slightly calcareous having organic carbon 0.28%, total nitrogen 0.032%, available P_2O_5 13.0 kg ha^{-1}, available K_2O 180 kg ha^{-1}, pH 7.5, electrical conductivity 0.20 dS m^{-1}, wilting point 6.0%, field capacity 19.2%, water holding capacity 28.3%, Bulk density 1.43 Mg m^{-1}, Particle density 2.60 Mg m^{-1} and porosity 45.6%. The field experiment was conducted in Split plot design with three replications. keeping cropping systems in main plot and sub plot in subplots. *A: Sowing methods (Main-plot)* S_1: Broad cast sowing, S_2: Line sowing and S_3: Cross sowing *B: Weed-management practices (Sub-plot)* W_1: Pendimethaline (1kg ha^{-1}) fb Sulfosulfuron (25g ha^{-1}) W_2: Clodinofop (60g ha^{-1}) fb 2,4-D (500g ha^{-1}), W_3: Pinoxaden (50 g ha^{-1}) fb Carfentrazone (30 g ha^{-1}), W_4: Two hand weeding (25 and 45 DAS) and W_5: Weedy check. Clean seed of wheat variety Halna-K7903 was sown at 20 cm rows distance at the sowing method of Line sowing, Cross sowing and Broad cast sowing seed rate with the help of seed drill. Crop was sown on December 15 and 17, during 2015 and 2016 growing seasons, respectively. Weeds were removed manually in two hand weeding at 25 and 45 days after sowing as per treatments during both years. Available moisture at sowing time up to 100 cm soil profile was measured which was 163.2 and 144.0 mm. The amount and distribution of rainfall received during cropping season was 212.0 and 243.4 mm in 2014-15 and 2015-16, respectively against the average annual rainfall of about 800 mm. Recommended package of practices and fertilizers doses were applied in different treatments.

The cost of cultivation was calculated by taking in to account the prevailing prices of the input and application cost of the relevant treatments. Economics of different treatments was worked out to assess the most viable and remunerative water harvesting technique.

Results and Discussion

The maximum tillers/plant & production tillers/plant were observed in S_3: Cross sowing followed by the treatment of S_2: Line sowing. The lowest tillers/plant & production tillers/plant was recorded under S_1: Broad cast sowing during the two different years of study. It was found in increasing order at 30, 60, 90 and tillers/plant & production tillers/plant during the two years of experimentation. The weed management practices maximum tillers/plant & production tillers/plant were found when W_4: Two hand weeding (25 and 45 DAS) was followed by W_2: Clodinafop (60g ha^{-1}) fb 2,4-D (500g ha^{-1}), W_3: Pinoxaden (50 g ha^{-1}) fb Carfentrazone (30 g ha^{-1}) and W_1: Pendimethaline (1kg ha^{-1}) fb Sulfosulfuron (25 g ha^{-1}) was applied and minimum tillers/plant & production tillers/plant was obtained from W_5: Weedy check. It was found in increasing order at 30, 60, 90 and tillers/plant & production tillers/plant during the two years of experimentation Sharma and Saroa, (2017) [5] & Rathore, (2001) [6].

The weed management practices significantly increased the number of spike/m^2 and number of grain/spike of wheat. The maximum number of spike/m^2 and number of grain/spike were observed in S_3: Cross sowing followed by the treatment of S_2: Line sowing. The lowest number of spike/m^2 and number of grain/spike was recorded under S_1: Broad cast sowing during the two different years of study. The weed management practices maximum number of spike/m^2 and number of grain/spike were found when W_4: Two hand weeding (25 and 45 DAS) was followed by W_2: Clodinafop (60g ha^{-1}) fb 2,4-D (500g ha^{-1}), W_3: Pinoxaden (50 g ha^{-1}) fb Carfentrazone (30 g ha^{-1}) and W_1: Pendimethaline (1kg ha^{-1}) fb Sulfosulfuron (25 g ha^{-1}) was applied and minimum number of spike/m^2 and number of grain/spike was obtained from W_5: Weedy check during the two years of experimentation Kumar *et al.*, (2012) [7] & Nizamani *et al.*, (2014) [8].

The maximum weight of spike (g) and spike length (cm) were observed in S_3: Cross sowing followed by the treatment of S_2: Line sowing. The lowest weight of spike (g) and spike length (cm) was recorded under S_1: Broad cast sowing during the two different years of study. The application of different practices of weed management significantly increased weight of spike (g) and spike length (cm) of wheat during the two years of experimentation. Among the weed management practices maximum weight of spike (g) and spike length (cm) were found when W_4: Two hand weeding (25 and 45 DAS) was followed by W_2: Clodinafop (60g ha^{-1}) fb 2,4-D (500g ha^{-1}), W_3: Pinoxaden (50 g ha^{-1}) fb Carfentrazone (30 g ha^{-1}) and W_1: Pendimethaline (1kg ha^{-1}) fb Sulfosulfuron (25 g ha^{-1}) was applied and minimum weight of spike (g) and spike length (cm) was obtained from W_5: Weedy check during the two years of experimentation, respectively Bharat *et al.*, (2012) [3], Singh *et al.*, (2016) [4], Paighan *et al.*, (2013) [9] & Pal *et al.*, (2012) [10].

The grain weight per spike (g) and 1000 – seed weight (g) was significantly affected by different sowing methods. Further, the weed management practices maximum grain weight per spike (g) and 1000 – seed weight (g) were found when S_3: Cross sowing followed by the treatment of S_2: Line sowing. The lowest spike length (cm) and weight of spike was recorded under S_1: Broad cast sowing during the two different years of study. The weed management practices maximum grain weight per spike (g) and 1000 – seed weight (g) were found when W_4: Two hand weeding (25 and 45 DAS) was followed by W_2: Clodinafop (60g ha^{-1}) fb 2,4-D (500g ha^{-1}), W_3: Pinoxaden (50 g ha^{-1}) fb Carfentrazone (30 g ha^{-1}) and W_1: Pendimethaline (1kg ha^{-1}) fb Sulfosulfuron (25 g ha^{-1}) was applied and minimum grain weight per spike (g) and 1000–seed weight (g) was obtained from Weedy check during the two years of experimentation.

Table 1: Effect of Sowing method and Weed Management Practices on Tillers/plant & production tillers/plant under different treatments.

Treatment	Tillers/ plant 30 DAS			Tillers/ plant 60 DAS			Tillers/ plant 90 DAS			Productive Tillers/plant		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
A. Sowing method												
Broadcast sowing -S1	2.52	2.60	2.56	4.02	4.21	4.11	4.29	4.39	4.34	3.98	4.08	4.03
Line sowing - S2	2.57	2.65	2.61	4.13	4.34	4.23	4.39	4.5	4.45	4.08	4.19	4.14
Cross sowing - S3	2.61	2.68	2.65	4.37	4.56	4.47	4.66	4.79	4.72	4.33	4.45	4.39
SE(m)	0.11	0.1	0.07	0.06	0.06	0.05	0.06	0.08	0.05	0.05	0.07	0.04
C.D.(P=0.05)	N.S.	N.S.	N.S.	0.25	0.25	0.15	0.24	0.26	0.16	0.21	0.27	0.14
B. Weed management Practices												
Pendimethaline(1kg/ha) fb Sulfosulfuron(25g/ha)-T1	2.51	2.60	2.56	4.07	4.26	4.16	4.34	4.45	4.39	4.04	4.14	4.09
Clodinofop(60g/ha)fb 2,4-D(500g/ha)-T2	2.62	2.70	2.66	4.26	4.45	4.35	4.56	4.68	4.62	4.24	4.36	4.3
Pinoxaden(50g/ha) fb Carfentrazone(30g/ha)-T3	2.58	2.66	2.62	4.16	4.35	4.26	4.45	4.55	4.50	4.14	4.23	4.19
Two hand weeding(25&45 DAS)-T4	2.75	2.85	2.8	4.61	4.84	4.73	4.91	5.05	4.99	4.57	4.7	4.64
Weedy Check-T5	2.37	2.42	2.39	3.77	3.94	3.86	3.99	4.08	4.04	3.66	3.76	3.71
SE(m)	0.11	0.13	0.09	0.07	0.08	0.05	0.09	0.11	0.07	0.06	0.08	0.05
C.D.(P=0.05)	N.S.	N.S.	0.26	0.20	0.23	0.16	0.27	0.32	0.21	0.18	0.22	0.15

Table 2: Effect of Sowing Methods and Weed Management practices on Number of Spike/m^2 and No. of Grain/spike under different treatment.

Treatment	Number of spike/m2			Number of grain/spike		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
	Mean	Mean	Mean	Mean	Mean	Mean
A. Sowing method						
Broadcast sowing -S1	319.9	321.39	320.64	42.3	42.66	42.48
Line sowing - S2	326.24	327.7	326.97	43.27	43.51	43.4
Cross sowing - S3	335.38	337.7	336.54	44.47	44.83	44.65
SE(m)	2.31	2.43	1.68	0.41	0.4	0.29
C.D.(P=0.05)	9.01	9.5	5.45	1.6	1.56	0.93
B. Weed management Practices						
Pendimethaline(1kg/ha) fb Sulfosulfuron(25g/ha)-T1	320.2	321.31	320.76	42.47	42.74	42.6
Clodinofop(60g/ha)fb 2,4-D(500g/ha)-T2	336.43	337.87	337.15	44.63	44.92	44.78
Pinoxaden(50g/ha) fb Carfentrazone(30g/ha)-T3	328.4	330	329.2	43.55	43.78	43.67
Two hand weeding(25&45 DAS)-T4	347.8	350.27	349.03	46.14	46.42	46.28
Weedy Check-T5	303.03	305.2	304.12	39.96	40.48	40.22
SE(m)	2.87	3.06	2.1	0.54	0.51	0.37
C.D.(P=0.05)	8.37	8.92	6.25	1.56	1.5	1.11

Table 3: Effect of Sowing Methods and Weed Management practices on weight of spike (g) and spike length (cm) under different treatment.

Treatment	Weight of Spike (g)			Spike Length(Cm)		
	2015-16	2016-17	POOLED	2015-16	2016-17	Pooled
	Mean	Mean	Mean	Mean	Mean	Mean
A. Sowing method						
Broadcast sowing -S1	1.79	1.83	1.81	8.06	8.11	8.09
Line sowing - S2	1.84	1.89	1.86	8.22	8.27	8.25
Cross sowing - S3	1.94	2	1.97	8.46	8.5	8.48
SE(m)	0.02	0.26	0.01	0.06	0.06	0.04
C.D.(P=0.05)	0.09	0.1	0.06	0.22	0.22	0.13
B. Weed management Practices						
Pendimethaline(1kg/ha) fb Sulfosulfuron(25g/ha)-T1	1.81	1.87	1.84	8.08	8.11	8.1
Clodinofop(60g/ha)fb 2,4-D(500g/ha)-T2	1.9	1.96	1.93	8.49	8.52	8.51
Pinoxaden(50g/ha) fb Carfentrazone(30g/ha)-T3	1.86	1.91	1.88	8.29	8.32	8.31
Two hand weeding(25&45 DAS)-T4	2.05	2.11	2.09	8.8	8.82	8.81
Weedy Check-T5	1.65	1.69	1.67	7.58	7.7	7.64
SE(m)	0.04	0.29	0.03	0.07	0.07	0.05
C.D.(P=0.05)	0.11	0.08	0.07	0.2	0.21	0.15

Table 4: Effect of Sowing method Weed Management practices and Grain weight/spike (g) and 1000-seed weight (g) under different treatment.

Treatment	1000-Seed weight (g)			Grain Weight/Spike(gm)		
	2015-16	2016-17	POOLED	2015-16	2016-17	POOLED
	Mean	Mean	Mean	Mean	Mean	Mean
A. Sowing method						
Broadcast sowing -S1	36.13	36.68	36.41	1.15	1.19	1.16
Line sowing - S2	36.84	37.00	36.92	1.78	1.21	1.19
Cross sowing - S3	37.87	38.03	37.95	1.25	1.28	1.26
SE(m)	0.23	0.24	0.16	0.01	0.2	0.00
C.D.(P=0.05)	0.88	0.92	0.53	0.05	0.06	0.03
B. Weed management Practices						
Pendimethaline(1kg/ha) fb Sulfosulfuron(25g/ha)-T1	36.14	36.29	36.22	1.16	1.2	1.18
Clodinofop(60g/ha)fb 2,4-D(500g/ha)-T2	38	38.16	38.08	1.22	1.26	1.24
Pinoxaden(50g/ha) fb Carfentrazone(30g/ha)-T3	37.07	37.22	37.15	1.19	1.22	1.21
Two hand weeding(25&45 DAS)-T4	39.28	39.44	39.36	1.32	1.36	1.34
Weedy Check-T5	34.23	35.08	34.66	1.06	1.08	1.07
SE(m)	0.33	0.35	0.24	0.01	0.02	0.01
C.D.(P=0.05)	0.97	0.61	0.72	0.04	0.04	0.03

Conclusion

Based on two years of experiment it may be inferred that Cross sowing supplemented with two hand weeding (25 and 45 DAS) in soil showed good potential for sustainable production and proved to be quite remunerative in irrigated alluvial tract of Uttar Pradesh.

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