Effect of inorganic and organic weed management practices on growth and economics in wheat (*Triticum aestivum* L.)

Comment [Mm1]: The content and method of editing the article is acceptable and it is better to use more up-to-date references.

Abstract

An experiment comprising twelve treatments *viz*., Sulfosulfuran 75WP@ 25g a.i., Sulfosulfuran 75WP + Metsulfuran 5WP @ 32g a.i. , Fenoxaprop 10WP @100g a.i., Pinoxaden 5EC @50g a.i. , Vesta (Clodinofop 15% propargyl + Metsulfuran 5WP @ 19.71ga.i., Halauxifen-Methyl 6.96% W/W + Pyroxsulam 25% WG@ 19.71g a.i.,Broadway (Carfentrazone ethyl 20% + Sulfosulfuran 25% WG @100 g a.i. each ha^{-1} at 30-35DAS, Paddy straw within two rows @6.0 t ha^{-1}, Polythene sheet within two rows both at 8-10DAS, Hand weeding (20 DAS and 40 DAS), Weed free, Unweeded Controlwas conducted in randomized block design with 3 replications at Crop Research Farm, Nawabganj, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (Uttar Pradesh) in wheat cv. K1006 during *Rabi* 2019-20. The growth characters plant height, number of effective tillers m^{-2} and dry matter accumulation (g m^{-2}) at 30, 60, 90 DAS and harvest of the crop and economics [Cost of cultivation (₹ ha^{-1}), gross income (₹ ha^{-1}), net income (₹ ha^{-1}) and B:C ratio] of the treatmentswere recorded. The maximum plant height (28.60, 70.95, 91.65 and 104.65cm), maximum effective tillers m^{-2} (184.64, 397.24, 427.76 and 418.23) and dry matter accumulation (98.60, 387.42, 748.34 and 1191.34 g m^{-2}) at above successive crop growth stages were recordedunder weed free practice. However, the net return (Rs.60776ha^{-1}) and B: C ratio (1.45) was higher with the use of polythene sheet. Thus, mulching with polythene sheet could be exploited as cost effective practice for sustaining wheat production.

Keywords: Dry matter, Growth, Herbicides, Paddy straw and Polythene sheet

1. Introduction

Wheat (Triticum aestivum L.), being an important prehistoric crop, is backbone of our national food security system. The idiom “Dal roti chalna” itself realized its significance in our livelihood. Its straw is accounted as a major feed to a large number of cattle. Thus, among the food grains, wheat is the richest source of protein and it stands at second place after pulses. 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%. 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. As such, wheat provides a major source of energy requirement of human diet and animal feed across the world.

Globally, wheat is cultivated approximatelyin 224 million hectares with an average annual global production of about 775.8 million metric tonnes (USDA- WAP 6-21). The largest producer of wheat in the world is the European Union followed by China, India and United States of America.In India, wheat is grown in 33.64 million hectares area with 107.86 million tons production and3206.30 kg ha^{-1} productivity during 2019-20**[2]**

Wheat cultivation stretches under wide range of agro-climatic conditions and thus, it has to encounter multifarious biotic and abiotic stresses.The presence of weed in a crop can adversely affect production in a number of ways. Weeds compete with crop plants for light, moisture, nutrient and space. Weed also increase harvesting costs, reduce quality of product and increase fire hazardous. In order to increase wheat yields, it is important to manage weed, which resulted higher yield in wheat crops. **[8].**

The several options like manual weeding and herbicide application are available for the efficient management of weeds applied before sowing and successive crop growth stages. Weed control is achieved through direct methods and also by adopting indirect methods such as altered land preparation, soil moisture regulation, planting methods, seeding rate and fertilizer management. In case of direct method of weed control, chemical method has an important role to reduce the weed population and increase the grain yield of wheat.

No doubt,the herbicides have provided effective control of weeds. But, due to continuous use of Isoproturon, Phalaris minor has become resistant to this herbicide **[9].** To overcome this problem, three alternate herbicides. Fenoxaprop-p-ethyl, Clodinafop-p-ethyl, Clodinafop-propargyl and Sulfosulfuron have been recommended for control of Isoproturon resistant Phalaris minor in rice-wheat growing areas **[4].** These herbicides performed very well against Isoproturon resistant Phalaris minor and restored wheat yields in north-west particularly in Haryana and Punjab **[4],[10] and [5].**Fenoxaoron and Clodinafop are specific to Phalaris minor and A. ludoviciana but ineffective against broad-leaved weeds.

Mulches are natural or manufactured layers of plant debris or other materials on soil. Mulches might be natural, synthetic, petroleum, conventional, inorganic, or organic. They are usually organic or inorganic mulch. Organic mulches are natural and can be decomposed by soil organisms, whereas inorganic mulches are man-made or rocks that cannot. Organic mulches supplement soil nutrients and fertility. Inorganic mulches, like plastic sheets, are durable and simple to handle, however they are non-recyclable and environmentally unfriendly. A mulched layer slows weed development by blocking light penetration, increases soil nutrients, preserves soil temperature, slows evaporation, and prevents soil erosion **[12].** Organic paddy straw mulch is weed-free. This is frequently accessible in winter after rice is harvested. When applied alone or as a mulch basis, paddy straw reduces weeds and increases soil moisture.

Soil mulching can significantly increase yields as well as WUE and NUE of wheat and maize by 20% and 60%, respectively. Though soil mulching has clear positive and rather consistent effects on yields, WUE and NUE of wheat and maize, there are also clear trade-offs. Straw mulching is limited by the availability of straw in the field, which is often being used also for feeding ruminants or as biofuel. Use of plastic films is limited by the financial cost, but also by the cost of the collection and recycling of the plastic residues. Therefore, guidelines for mulching practices should consider the effects of water and N input levels, crop type and the sideeffects of mulching.

2. Materials and Methods

The present investigation was conducted at Crop Research Farm, Nawabganj of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, (U.P.) India during *Rabi* season of 2019-20, with the objective to find out the optimum organic and or inorganic weed management practices to sustain wheat yield and profitability under current scenario of resilient agriculture. The treatments *viz.*, Sulfosulfuran 75WP@ 25g a.i., Sulfosulfuran 75WP + Metsulfuran 5WP @ 32g a.i., Fenoxaprop 10WP @100g a.i., Pinoxaden 5EC @50g a.i., Vesta (Clodinofop 15% propargyl + Metsulfuran 5WP @ 19.71ga.i., Halauxifen-Methyl 6.96% W/W + Pyroxsulam 25% WG@ 19.71g a.i., Broadway (Carfentrazone ethyl 20% + Sulfosulfuran 25% WG @100 g a.i. each ha^{-1} at 30-35DAS, Paddy straw within two rows @6.0 t ha^{-1}, Polythene sheet within two rows both at 8-10DAS, Hand weeding (20 DAS and 40 DAS), Weed free, Unweeded Controlwere experimented on growthandeconomics in wheat. The experimentcomprising above 12 treatments was laid out in randomized block design with 3 replications. The gross and net plot size were 10.0 × 3.0 m² and 9.0 × 2.40 m², respectively. A dose of 75 kg Nitrogen, 60 kg Phosphorus and 40 Kg Potash was applied as basal dressing and remaining dose of Nitrogen (75 kg) was applied into two equal split doses. Four irrigations were supplemented at or about CRI stage, tillering stage, late jointing stage and flowering stage. The wheat variety K 1006 was sown @ 100 kg seed ha^{-1} with 20 cm spacing between rows, on 28 November, 2019 and harvested on 29th April 2020. The soil of experimental field was sandy loam with pH 7.8. The soil is low in organic carbon (0.49), low nitrogen, medium in available phosphorus (19.30 kg ha^{-1}) and potash (180.50 kg ha^{-1}).The relevant data were recorded as below:

2.1 Growth characters

2.1.1 Plant height (cm)

Ten plants randomly selected in net area were tagged and the height of the main shoot was measured in cm from ground level to the tip of main shoot at 30, 60, 90 DAS and at harvest of crop and average height of main shoot was calculated.

2.1.2 Number of effective tillers m^{-2}

Number of effective tillersm^{-2} were counted at three randomspots in each plot by taking row in the length of one meter × width of one meter were averaged over to find out total effective tillers per meter^{2}.

2.1.3 Dry matter accumulation (g m^{-2})

For recording dry matter accumulation three sample were randomly selected from the sampling rows and uprooted from ground level with the help of sharp knife at different crop growth stages i.e. 30, 60, 90 DAT and at harvest. The destructive samples of such plants were oven dried at 70 °C for 24 hours and weighed. The weight thus obtained is expressed as dry matter accumulation g m^{-2}

2.1 Economics

2.2.1 Cost of cultivation (₹ ha^{-1})

The cost of cultivation was worked out treatment wise. The common cost of cultivation to all treatments was added to the respective additional cost involved in each treatment.

2.2.2 Gross income (₹ ha^{-1})

The gross income was calculated plot wise. For this purpose, grain and straw was converted into rupees per hectare at prevailing market price of wheat grains and straw.

2.2.3 Net income (₹ ha^{-1})

For obtaining the net income, the cost of cultivation was subtracted from the gross income of each treatment.

$$\textit{Net income } (₹\ ha^{-1}) = \textit{Gross income} - \textit{Cost of cultivation}$$

2.2.4 B: C ratio

For the calculation of cost benefit ratio, the grass return was divided with the cost of cultivation. The value obtained was considered as cost benefit ratio.

$$B{:}\,C\ ratio = \frac{Gross\ income}{Cost\ of\ cultivation}$$

2.3. Statistical analysis of data

Data recorded related to crop and weed studied during the course of study were subjected to statistical analysis as per method of analysis of variance, as suggested by Fisher**[6].**

3. Results and Discussion

3.1 Growth parameters

3.1.1 Plant height (cm):

The plant height was found to be increased significantly in comparison to unweeded control (89.80 cm). The maximum plant height (104.65 cm) was recorded under weed free condition closely followed by hand weeding (103.85 cm), use of polythene sheet (103.45 cm), Broadway (Carfentrazone ethyl 20% + Sulfosulfuron @ 25/WG @ 100 g a.i. ha^{-1}) (102.95 cm) and Halauxifen methyl 6.95% + w/w Pyroxsulam 25% w/w/WG @ 19.71g a.i. ha^{-1}at 35 DAS (102.72 cm). **[1], [3], [13]** and **[14]** also reported the increased plant height after the adoption of similar weed management practices over weedy check in wheat.

3.1.2 Number of tillers (m^{-2})

The weed free treatment registered the maximum number of tillers at all the growth stages of the crop as compared to other treatments. Further, weed management practices in general increased the significant number of tillers over the unweeded control (314.52). Besides, among treatments, hand weeding produced the maximum number of tillers (411.23) followed by Broadway (Carfentrazone ethyl 20% + Sulfosulfuron @ 25/WG @ 100 g a.i. ha^{-1}) (403.43) and at par by use of polythene sheet (401.65) and Sulfosulfuron 75wp @ 25g a.i.

ha^{-1} (401.54). The combination of Halauxifen methyl 6.95% w/w + Pyroxsulam 25% w/w/WG @19.71g a.i. ha^{-1} at 35 DAS, and Sulfosulfuron 75wp + Metsulfuron 5wp @ 32g a.i. ha^{-1} showed almost at par number of tillers. It was also noticed that the number of tillers were increased up to 90th day of crop growth and thereafter, it decreased slightly, which might be due to the not bearing ability of their panicles. Similar results have also been reported by **[1], [16],[11]** and **[13].**

3.1.3 Dry matter accumulation (g m^{-2}):

The dry matter accumulation in crop was increased at all the growth stages. The maximum dry weight (1191.34 g m^{-2}) was recorded under weed free practice followed by the application of inorganic treatment Broadway (Carfentrazone ethyl 20% + Sulfosulfuron @ 25/WG @ 100g a.i. ha^{-1}) (1128.87 g m^{-2}), hand weeding (1118.76 g m^{-2}) and Sulfosulfuron 75wp @ 25g a.i. ha^{-1}(1116.98 g m^{-2}). The organic practices showed the comparatively less dry matter accumulation as compared to aforesaid inorganic as well as hand weeding practices. However, all the weed management practices significantly enhanced the dry matter accumulation over unweeded control. It means that the weeds hampered significantly the components responsible for dry matter accumulation. Similar results have also been reported by **[13]** and **[14].**

3.2 Economics

The maximum cost of cultivation (₹ 50, 519 ha^{-1}) was incurred under weed free against the lowest cost of cultivation of unweeded check (₹ 38875 ha^{-1}). In all weed management practices recorded higher gross return, net return and benefit cost ratio over unweeded check. The maximum gross return of ₹ 110206.25 ha^{-1}was obtained with weed free closely followed by hand weeding (₹ 106356.25 ha^{-1}) against lowest gross income of ₹ 62716.50 ha^{-1} of unweeded check.The use of polythene sheet treatment recorded the highest net return of ₹ 60776.00 ha^{-1} closely followed by weed free (₹ 59831.25ha^{-1}), Broadway (Carfentrazone ethyl 20% + Sulfosulfuron 25 WG @ 100 g ha^{-1}) (₹ 59751 ha^{-1}) and hand weeding (₹ 59751 ha^{-1}) against the lowest net return of ₹ 23841.50ha^{-1} noted under unweeded check. It is interesting to accord that the adoption of polythene sheet and Broadway (Carfentrazone ethyl 20% + Sulfosulfuron 25 WG @ 100 g ha^{-1}) also rerecorded equally highest benefit cost ratio (based on net return) of 1.45 followed by Halauxifen methyl 6.95% W/W+ Pyroxsulam 25% WG @ 19.71g a.i. ha^{-1} (1.43), paddy straw (1.42) and Sulfosulfuron 75wp + Metsulfuron Methyl 5WP @ 32g a.i. ha^{-1} (1.41). It is also appeared worthy that the treatments like weed free and hand weeding were not found to be economical in comparison to the organic as well as inorganic weed management practices because of high expenditure involved in keeping the plots free of weeds and in hand weeding. In the organic and inorganic weed management practices, the better net return and return per rupee investment was mainly due to less increase in cost of cultivation as compared to weed free and hand weeding.**[1]** and **[15]** also reported similar results. Further, mulching soil with straw and plastic film can sustain wheat yield and profitability **[7].**

4. Conclusion

Keeping above findings in view, it is concluded that the among all the treatments, weed free treatment was found best. But in economic terms the treatment containing Broadway (Carfentrazone ethyl 20% + Sulfosulfuran 25 WG @ 100 g ha^{-1}) and treatment with Useof PolytheneSheetwithin tworows ofwheat were found the best.

References

1. **Ali M., Sabir, S., Kumar, M. and Ali, M.A. (2006).** Efficacy and economics of different herbicides aga.i.nst narrow leaved weeds in wheat. International Journal of Agriculture and Biology. 4: 647-651.

2. **Anonymous (2020).** *The Economic Times: Business News, Personal Finance, Financial News, India Stock Market Investing, Economy News, SENSEX, NIFTY, NSE, BSE Live, IPO News*. (n.d.). https://economictimes.indiatimes.com/defaultinterstitial.cms
3. **Bibi, S., Khan, B.M., Gul, H. and Khan, N.M. (2008).** Effect of herbicides and wheat population on control of weeds in wheat. Pakistan Journal of Weed Science and Research.14 (3&4): 111-119.
4. **Chhokar, R.S. and Malik, R.K. (2002).** Isoproturon resistant linie seed canary grass (Phalaris minor) and its response to alternate berbicides Weed Technology. 16: 116-123.
5. **Chhokar, R.S., Sharma, R.K., Chauhan, D.S. and Morgia, A.D. (2006).** Evaluation of herbicide aga.i.nstPhalaris minor in wheat in North Western Indian Pla.i.ns. Weed Research. 46: 40-49.
6. **Fisher, R.A. (1937).** The Design of Experiments. Hafner Press. Macmillan Publishing Co. Inc. New York. Second Edition 1937.
7. **Javed, A., Iqbal, M. and Shehzadi, R. (2020).** Effect of plastic film and straw mulch on wheat yield, water use efficiency and soil properties in Punjab, Pakistan. Journal of Bio Resource Management. 7(4):63-73.
8. **Khan, M.A. (2003).** Wheat crop management for yield maximization. Agriculture Department, Lahore.Pub. Wheat Research Institute, Fa.i.salabad., pp. 4-5.

9. **Malik, R.K., Balyan, R.S. and Shan, V. M. (1988).** Effect of surfactants on the efficacy of some post emergence gross herbicide. Haryana Agricultural University Journal of Research. 18:276-283.
10. **Malik, R.S.; Yadav, A.; Malik, R.S. and Singh, S. (2005).** Efficacy of clodinafop, fenoxaprop, sulfosulfuron and trisulfuron alone and as tank mixture aga.i.nst weed in wheat. Indian Journal of Weed Science. 37(314): 180-183.
11. **Malik, R.S.; Yadav, A.; Kumar, R.; Hasija, R.C. and Hooda, V.S. (2012).** Performace of different herbicides for the control of complex weed flora in wheat. Environment and Ecology 30(3A): 717-721.
12. **Ossom, E. M., Pace, P. F. Rhykerd, R. L. and Rhycerd, C. L. (2001).** Effect of mulch on weed infestation, soli temperature, nutrient concentration, and tuber yield in Ipomoea batatas (L.) Lam. In Papua New Guinea. Tropical. Agriculture. (Trinidad).2001. 78; 144-151.
13. **Pal, S., Sharma, R., Sharma, H. B. and Pankaj (2012).** Bio-efficacy and selectivity of different berbicides for weed control in wheat. International Agronomy Congress 2:48-49.
14. **Saquib, M., Bhilane, R.L. and Thawal, D.W. (2012).** Growth and productivity of wheat as influenced by weed management. Indian Journal of Weed Science. 44 (2): 126-128.
15. **Tomar, S.K and Tomar, T.S. (2014).** Effect of herbicides and their tank mix mixture on weed dynamics and yield of zero-tilled wheat (Triticumaestivum) under rice-wheat cropping system of eastern Utter Pradesh, Indian Journal of Agronomy. 59 (4): 624-628.
16. **Walia, U.S., Kaur, T., Nayyar, S. and Kaur, R. (2011)** Performance of ready-mix formulation of Fenoxaprop-p-ethyl Metribazin for the control of grass and broad leaf weeds in wheat. Indian Journal of Weed Science. 43 (1&2): 41-43.

Comment [Mm2]: Article references need to be updated.

Table 1: Effects of inorganicinorganic and organic weed management practices on growth characteristics in wheat cv. K 1006.

Treatment	Plant height (cm)				Number of effective tiller (m^{-2})				Dry matter accumulation ($g\ m^{-2}$)			
	30 DAS	**60 DAS**	**90 DAS**	**At harvest**	**30 DAS**	**60 DAS**	**90 DAS**	**At harvest**	**30 DAS**	**60 DAS**	**90 DAS**	**At harvest**
Sulfosulfuron75wp @25 ga.i. ha^{-1} at 35 DAS	26.55	69.35	89.95	102.45	183.46	381.67	411.39	401.54	97.22	368.88	697.17	1116.98
Sulfosulfuron75wp +Metsulfuron5wp @ 40 ga.i.ha^{-1}at35 DAS	26.05	68.55	89.00	101.95	182.92	375.93	402.56	396.34	96.98	358.45	648.91	1089.76
Fenoxaprop10wp @100g ha^{-1}at35 DAS	25.55	67.45	87.12	101.16	180.42	364.98	389.98	379.45	96.36	305.65	602.22	1038.23
Pinoxaden5EC@50gha^{-1}at35 DAS	25.30	66.40	86.75	101.05	178.12	351.98	386.12	377.34	96.14	290.89	584.95	1015.98
Vesta(Clodinofoppropargyl15%+ Metsulfuron5wp @19.71g ha^{-1}at35 DAS	25.75	67.85	87.35	101.28	182.12	368.76	392.74	381.34	96.52	335.24	628.67	1052.65
Halauxifenmethyl 6.95 %w/w + Pyroxsulam25%w/w/WG @19.71ga.i. haat 35 DAS	26.30	68.95	89.55	102.12	183.18	378.76	407.78	397.24	97.12	362.74	678.12	1095.72
Broadway(Carfentrazoneethyl20%+ Sulfosulfuron25WG@100gha^{-1}at35 DAS	26.90	69.55	90.25	102.95	183.67	386.29	414.48	403.43	97.38	372.98	712.34	1128.87
Useofpaddy strawwithintwo rowsofwheat @ 6.0 t/ha	25.90	68.10	87.88	101.55	182.75	371.56	396.67	384.29	96.78	391.98	811.32	1112.91
Useof PolytheneSheetwithintwo rows of wheat	27.25	69.85	90.85	103.45	183.98	389.66	419.81	401.65	97.58	376.98	723.76	1102.87
Handweeding(20DASand40 DAS)	27.80	70.10	91.10	103.85	184.12	394.76	423.67	411.23	97.96	381.54	740.88	1118.76
Weedfree	28.60	70.95	91.65	104.65	184.64	397.24	427.76	418.23	98.60	387.42	748.34	1191.34
Unweeded Control	25.10	65.50	85.75	89.80	173.76	281.76	336.12	314.52	95.98	273.78	563.88	814.72
Mean	26.42	68.55	88.93	101.36	181.93	370.28	400.76	388.88	97.05	350.54	678.38	1073.23
SEm±	**0.64**	**0.96**	**1.26**	**1.71**	**1.32**	**6.74**	**6.50**	**5.39**	**0.64**	**13.35**	**5.48**	**21.04**
C.D.at5%	**1.61**	**2.34**	**3.12**	**4.21**	**3.22**	**16.61**	**15.98**	**13.24**	**1.56**	**32.46**	**43.72**	**51.15**

Table 2: Effects of inorganic and organic weed management practices on economics in wheat cv. K 1006.

Treatment	Cost of cultivation (₹ ha^{-1})	Gross return (₹ ha^{-1})	Netreturn (₹ ha^{-1})	B:Cratio
Sulfosulfuron75%wp @25g a.i. ha^{-1}at 35 DAS	40493	96943.00	56450.00	1.39
Sulfosulfuron 75wp + MetsulfuronMethyl5wp@ 32g a.i.ha^{-1}at 35 DAS	40859	98560.00	57701.00	1.41
Fenoxaprop10wp@100ga.i. ha^{-1}at 35 DAS	40139	94902.50	54763.50	1.36
Pinoxaden5.1%EC@50g a.i. ha^{-1}at 35 DAS	40119	93362.50	53243.50	1.33
Vesta(Clodinofoppropargyl15 %+Metsulfuron5 wp@ 19.71ga.i. ha^{-1}at35 DAS	41069	96635.00	55566.00	1.35
Halauxifenmethyl6.95 %W/W +Pyroxsulam25 %WG@ 19.71ga.i. haat 35 DAS	40769	98945.00	58176.00	1.43
Broadway(Carfentrazoneethyl 20%+Sulfosulfuron25WG @ 100 gha^{-1}at 35 DAS	41119	100870.00	59751.00	1.45
Usepaddy strawwithin two rowsofwheat @6.0 t/ha	40121	97212.50	57091.50	1.42
Useof PolytheneSheetwithin tworows ofwheat	42019	102795.00	60776.00	1.45
Handweeding(20DASand40 DAS)	47019	106356.25	59337.25	1.26
Weedfree	50375	110206.25	59831.25	1.18
Unweeded Control	38875	62716.50	23841.50	0.61