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Varieties and mulching influence on weed growth in wheat under Indo-Gangetic plain of India

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Abstract: Weeds are one of the primary factors responsible for reducing wheat yield. Despite, herbicides' being one of the important components of weed management programme in India, but it was not adopted by resource poor farmers. Keeping these facts in view, a field experiment was carried out at Agricultural research farm, Institute of Agricultural sciences, Banaras Hindu University during the *rabi* (winter) season of the year 2012-13 to scrutinize the influence of 'mulching' and 'varieties' on weed control potential as well as growth and yield of wheat. The treatments comprised of five wheat varieties (C-306, K-8027, K-0307, DBW-39 and HD-2888) and four mulching treatments (No -mulch, paddy straw 6t/ha, maize straw 6t/ha, and saw dust 6t/ha). Surface application of paddy straw mulch 6t/ha considerably reduced the density and biomass of broad leafed weeds and grasses and showed higher weed control efficiency over other treatments like maize straw 6t/ha, saw dust 6t/ha and no-mulch. Varieties DBW-39 and K-0307 was highly effective in smothering of the weeds and produced higher dry matter accumulation, leaf area index, number of grain/earhead, biological yield and harvest index of wheat.

Keywords: Cultivars, Maize straw, Paddy straw, Saw dust, Weed control efficiency

INTRODUCTION

Wheat is one of the most important agricultural crops in India. It accounts for 12 per cent of the total cultivable land area, contributes 3 per cent in the country's gross domestic product (GDP) (Singh *et al.,* 2013); and moreover,it is one of the important source of energy and protein (Sharma *et al.,* 2008). Recent report showed that India's wheat production has reached to 96 M tons from an area of 29 Mha with an average productivity 2.7 t/ha (Swaminathan, 2013). But, to fulfill the demand of burgeoning population, wheat production needs to be increase by 110–120 M tons by 2051 A. D.; by that time it is expected the area under wheat production decreased by 5–6 M ha. Thus average wheat productivity needs to increase up to 5 t/ha to feed the population (Sharma *et al*., 2013). Weeds caused serious threat to wheat production (Kumar *et al.,* 2008); accounts for 20-40 per cent losses in wheat yield (Sharma, 2009). Therefore, for realizing full genetic yield potential of the crop and sustaining food grain production to feed the ever-increasing population, weed management is essential (Singh and Chhokar, 2012).

Because of higher economic cost of labour for manual weeding, herbicides are widely preferred by farmers (Singh et al. 2014), but its continuous usage for longer duration leads to shift in weed flora, increase in residual toxicity to the succeeding crops (Chhokar *et al*., 2006), development of herbicide resistance in weeds (Singh, 2007) and also increase the cost of crop production (Vincent and Quirke, 2002). Therefore, these situations force the researchers to search some economically viable, ecological sustainable and technologically feasible options of weed management in wheat.

Use of mulch and competitive varieties has potential to sustainably manage the weeds at low cost. Plenty of organic mulch materials *viz.* paddy straw, maize straw and saw dust are easy accessible to the farmers of eastern Uttar Pradesh in their villages. In fact researches showed that application of paddy straw mulch 6 t/ha (Brar and Walia, 2010) reduced biomass and density of weeds in wheat. In addition, organic mulches improve the physical, chemical and biological properties of soil (Kasirajan and Ngouajio, 2012) and increase the crop yield (Brar and Walia, 2010).

Futhermore, selection of appropriate crop varieties may have a profound effect on crop-weed competition. Varietal characteristics, like, taller plant height, size of flag leaf, higher leaf size and leaf area index, high specific leaf area during vegetative growth, and allelopathic ability (Joshi *et al*., 2007, Bertholdsson and Brantestam, 2009) makes one variety more competitive with weeds than another.

Literature reveals that there are meager studies conducted in wheat to evaluate the effect of varieties and mulch materials on weed and crop growth. Keeping

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above facts in view, present investigation was carried out with the objective to evaluate the weed suppression ability and crop response of different mulches and varieties of wheat.

MATERIALS AND METHODS

Site and soil information: The experiment was carried out during winter season (*Rabi*) season of 2012–13 at Agricultural research farm, Institute of Agricultural sciences, Banaras Hindu University, Varanasi (U.P), situated in Indo-Gangetic plain ($25^0$18'N, $83^0$03'E, 128.93 m amsl). The soil of the experimental site was sandy clay loam, organic carbon 0.52%, pH 8.53, available NPK 175.56, 22.1, 227.5 kg/ha, respectively. The weather in this area is characterized by hot, dry summers and cold winters. During crop growth period, maximum and minimum temperature ranges from 39.2—17.1^{0}C and 5.8—21.1^{0}C, respectively. Maximum (39.2^{0}C) and minimum (5.8^{0}C) temperature recorded in month of April and January, respectively. Total rainfall received during the crop growing period was 22.1 mm, and average evaporation during the period of experimentation varied from 0.9 to 7.2 mm per day.

Trial establishment: The experiment was laid out in two factor factorial completely randomized block design, having plot size 4×3 m with three replications. First factor comprised of five wheat varieties (C-306, K-8027, K-0307, DBW-39 and HD-2888) whereas, second factor consist of four mulching treatments [No-mulch (NM), paddy straw 6t/ha (PSM), maize straw 6t/ha (MSM), and saw dust 6t/ha (SDM)]. Quantity of mulch materials was quantified on dry weight basis. Recommended seed rate (100 kg/ha) of wheat was sown at 5 cm depth in open furrows made with a manual single row drill at a row spacing of 22.5 cm and immediately covered with soil on December 06, 2012. Mulch material was applied immediately after sowing of wheat. Recommended rates of fertilizers 120 kg N, 60 kg P_2O_5 and 40 kg K_2O /ha were applied through urea, single super phosphate, and muriate of potash, respectively. Whole of phosphorus and potassium and half rate of nitrogen were applied at the time of sowing. The remaining half -rate of nitrogen was applied as top dressing at 22 DAS (CRI stage) and 46 DAS (booting stage). Crop was harvested on 29 April, 2013.

Biometerical observation: Data on weed density and biomass were recorded at 60 DAS. Weed samples were randomly collected from 2-places in each plot with the help of quadrate (size 31.62 x 31.62 cm). To estimate the density of weeds, uprooted weed samples were classified under broadleaf, grasses and sedges thereafter counted and values were presented in number/m^2. Uprooted weed samples were placed in a paper bag, and dried for 48 h in an oven at 60^{0}C, then weighed to determine weed biomass and values are presented in g/m^2. The weed control efficiency (WCE) was calculated on the basis of reduction in weed biomass in treated plot as compared to control (no-mulch) plot and express in percentage (Anwar *et al*., 2013). Similar formula is also used to estimate the WCE on density basis, where density of weeds was taken in account instead of biomass.

Dry matter accumulation by wheat was recorded at 30 and 60 DAS, whereas, leaf area index (LAI) was recorded at 60 DAS. Wheat dry matter was taken from above ground plants samples, from random selected area of 1 meter in running length for wheat crop. The samples were sun dried and then dried in oven at 60^{0}C till a constants weight was obtained, then values were converted to g/m^2. LAI was measured from 5-spots in intra-row spaces of wheat crop using AccuPar PAR/LAI ceptometer model: LP-80, which calculates LAI based on the above and below-canopy PAR measurements (Singh *et al.,* 2015). Thereafter, values from each plot are averaged to obtain a single value. Yield attributing parameters like, spike length (earhead) and number of grain/earhead was obtained from five randomly selected ears from each plot and their length and number of grain per earhead were recorded. Biological yield (kg/ha) (BY*d*) was calculated after harvesting above ground plant parts from net plot area of each plot and values were expressed into kg/ha. However, harvest index (HI) was calculated as per the formula suggested by (Unkovich *et al*., 2010).

Statistical analysis: Data was collected on wheat and weeds were tabulated and statistically analyzed as per the standard analysis of variance to draw valid conclusions (Gomez and Gomez, 1984). The treatment differences were tested by 'F' test of significance on the basis of null hypothesis. Critical differences were work out at 5 per cent level of probability where 'F' test was significant. Heterogeneous weed (density and biomass) data were square-root transformed i.e. $\sqrt{(X+0.5)}$, prior to analysis to produce a near normal distribution, however, non-transformed data are also presented for clarity.

RESULTS AND DISCUSSION

Effect on weed: The experimental field during the cropping season was infested with 7-winter (*rabi*) season weeds. Predominant weed species among the grasses are *Phalaris minor* Retz. and *Cynodon dactylon* (L) Pers whereas, *Chenopodium album* L, *Melitlotus* sp. *Parthenium hysterophorus* L. and *Rumex dentatus* L. among broadleaf weeds (BLWs). Moreover, among sedges only one species *Cyperus rotundus* L. was observed.

Varieties: Wheat varieties C-306, K-8027 and HD-2888 showed significantly highest density and biomass of BLWs and grassy weed; however, except HD-2888 showed relatively lower biomass of grassy weeds as compared to C-306, K-8027 (Table 1). Whereas, lowest density and biomass of BLWs and grassy weeds were observed under DBW-39 and was statistically

Table 1. Effect of varieties and mulching on density and biomass of broadleaf, grasses, sedges and WCE in wheat.

Treatment	Density (number/m^2)[a]				Biomass(g/m^2)[a]			
	BLWs	Grasses	Sedges	WCE (%) (density basis)	BLWs	Grasses	Sedges	WCE (%) (biomass basis)
Varieties								
C-306	9.26 (85.42)	4.38 (18.75)	1.95 (3.33)	3.48	4.50 (19.82)	3.16 (9.53)	0.89 (0.30)	29.81
K-8027	9.57 (91.25)	4.24 (17.50)	2.43 (5.42)	14.07	4.40 (18.91)	2.44 (5.50)	0.93 (0.38)	37.55
K-0307	6.98 (48.33)	3.54 (12.08)	2.34 (5.00)	32.43	3.20 (9.80)	2.68 (6.69)	1.00 (0.51)	34.45
DBW-39	7.67 (58.33)	3.30 (10.42)	2.90 (7.92)	31.92	3.71 (13.30)	2.03 (3.66)	0.92 (0.36)	42.70
HD-2888	8.87 (78.33)	3.48 (11.67)	2.34 (5.00)	23.23	4.22 (17.33)	2.23 (4.48)	0.97 (0.46)	28.70
SEm±	0.62	0.21	0.09	-	0.26	0.16	0.05	-
CD (P=0.05)	1.78	0.59	0.26	-	0.75	0.46	NS	-
Mulching								
No- Mulch	9.61 (92.00)	4.02 (15.67)	3.24 (10.00)	0.00	5.00 (24.57)	3.29 (10.33)	1.14 (0.80)	0.00
Paddy straw 6t/ ha	6.62 (43.33)	3.93 (15.00)	1.08 (0.67)	54.24	2.87 (7.76)	1.81 (2.80)	0.77 (0.10)	69.47
Maize straw 6t/ ha	7.19 (51.33)	3.34 (10.67)	2.12 (4.00)	38.05	3.32 (10.55)	2.31 (4.86)	0.88 (0.28)	53.80
Saw dust 6t/ha	10.15 (102.67)	3.93 (15.00)	2.67 (6.67)	-8.18	4.57 (20.45)	2.52 (5.89)	0.96 (0.43)	15.30
SEm±	0.56	0.18	0.08	-	0.24	0.14	0.04	-
CD (P=0.05)	1.60	0.53	0.23	-	0.67	0.41	0.13	-
V×M	NS	NS	NS	-	NS	NS	NS	-

Data is subjected to square root transformation ($\sqrt{x+0.5}$) and non transformed data is mentioned in the parenthesis
[a] Observation recorded at 60 DAS

Table 2. Effect of varieties and mulching on plant growth parameter, yield attributes and yield.

Treatments	Growth parameter			Yield attributes		Yield	
	Plant dry matter(g/m^2)		Leaf area index (LAI)	Spike length (cm)	Number of grain/ earhead	Biological yield (kg/ ha)	Har-vest index (%)
	30 DAS	60 DAS	60 DAS				
Varieties							
C-306	14.22	254.33	2.51	15.35	39.75	72.05	37.29
K-8027	15.11	305.89	2.43	15.75	41.50	78.35	38.66
K-0307	23.03	294.75	3.06	14.62	43.50	83.58	36.74
DBW-39	18.14	239.87	2.77	13.05	45.50	106.68	37.21
HD-2888	19.19	302.97	2.89	14.52	38.50	74.40	36.90
SEm±	1.94	31.12	0.18	0.27	0.66	1.32	0.57
CD (P=0.05)	5.54	NS	0.52	0.76	1.88	3.78	1.64
Mulching							
No- Mulch	16.35	242.74	2.46	14.61	35.40	71.80	34.57
Paddy straw 6t/ha	19.27	304.44	2.89	14.55	47.20	87.90	41.54
Maize straw 6t/ha	18.03	259.74	2.67	14.87	44.00	88.88	37.71
Saw dust 6t/ha	18.10	311.32	2.90	14.60	40.40	83.46	35.62
SEm±	1.73	27.83	0.16	0.24	0.59	1.18	0.51
CD (P=0.05)	NS	NS	NS	NS	1.68	3.38	1.47
V×M	NS	NS	NS	NS	NS	S	NS

Table 3. Integrated effects of varieties and mulching on biological yield.

Varieties	Biological yield(kg/ha)			
	Mulching			
	No-Mulch	Paddy straw 6t/ha	Maize straw 6t/ha	Saw dust 6t/ha
C-306	66.00	76.80	75.40	70.00
K-8027	58.00	84.40	90.00	81.00
K-0307	76.00	90.50	86.40	81.40
DBW-39	78.00	112.80	117.00	118.90
HD-2888	81.00	75.00	75.60	66.00
CD (P=0.05)			7.55	

similar to K-0307, except for biomass of grassy weeds. Biomass accumulation by sedges under different wheat varieties differed non-significantly; however, significantly highest and lowest density of sedges were recorded under DBW-39 and C-306, respectively, although rest of the varieties showed at par density of sedges among themselves. Highest WCE (on density basis) observed under variety K-0307 followed by DBW-39 and HD-2888, however, highest WCE (on biomass basis) recorded under DBW-39 followed by K-0307. Variety C-306 showed lowest WCE.

Mulch: Application of SDM and NM treatments produced highest density and biomass of BLWs and grasses, except biomass produced by grasses under SDM was statistically lower than NM ($P<0.05$) (Table 1). Application of PSM and MSM produced at par lower density and biomass of BLWs and grasses. In fact, biomass produced by grassy weeds was comparatively lower under MSM over PSM. Significantly highest density and biomass of sedges was observed under NM followed by SDM, whereas, lowest sedges growth was observed under PSM. Highest WCE on both density and biomass was observed under PSM followed by MSM.

Effect on crop Varieties: Plant dry matter (DM) accumulation did not differed significantly with wheat varieties at 60 DAS (Table 2). However, significantly higher plant DM accumulation at 30 DAS and LAI at 60 DAS was produced by K-0307, and it was statistically at par to DBW-39 and HD-2888, furthermore, variety C-306 produced lowest DM accumulation and LAI and was statistically similar to the varieties K-8027, DBW-39 and HD-2888.

Significantly highest spike length was produced by the variety C-306 and K-8027, whereas, lowest spike length was produced by DBW-39. Contrary to spike length, significantly highest number of grain/earhead produced by the variety DBW-39 followed by K-0307, C-306 and K-8027; later two varieties showed at par results. Wheat variety DBW-39 produced significantly highest BY*d* followed by K-0307, whereas, lowest BY*d* was recorded under C-306 followed by HD-2888. Moreover, wheat variety K-8027 produced highest HI was observed under varieties K-8027and was statistically similar to DBW-39 and C-306; however, lowest HI was observed under HD-2888 and it was statistically similar to DBW-39 and C-306.

Mulch: Application of different mulch materials did not showed marked influence on plant dry weight, LAI and spike length of wheat (Table 2). However, application of the PSM produced higher number of grain/earhead followed by MSM, SDM and NM treatment, respectively. Application of both PSM and MSM produced statistically similar highest BY*d*. However, lowest BY*d* was obtained under NM. Further, observation on HI clearly revealed significantly highest values obtained under PSM followed by MSM, whereas, significantly at par lowest HI observed under SDM and NM treatments.

Integrated effects of varieties and mulching on biological yield: Interaction of variety x mulching showed that different mulches x DBW-39 produced statistically at par BY*d*, however, at the same time, different mulch X DBW-39 produced higher BY*d* over NM x DBW-39 (Table 3). Almost similar BY*d* was produced under the variety K-8027 and K-307 in combination with different mulches and was significantly lower over DBW-39 x different mulches. SDM in combination with the variety C-306 and HD-2888 recorded lowest BY*d* and both these combinations showed statistically at par results.

Experimental findings indicated that during initial stage of crop growth due to higher early plant vigour the variety DBW-39 followed by K-0307 showed higher dry matter accumulation and LAI as compared to the rest of the varieties. Even these varieties i.e. DBW-39 and K-0307 maintain higher LAI throughout crop growth stages (data not shown). Higher plant growth under DBW-39 and K-0307 negatively affect weed growth, particularly, BLWs and grasses which contribute to the maximum density and biomass accumulation by weeds. Similar to our findings, Lemerle *et al.* (1996) tested 250 genotypes of wheat for competitiveness against *Lolium rigidum*, they concluded that strongly competitive genotypes had high early biomass accumulation with extensive leaf display. Andrew *et al.* (2015) also opined that early plant vigour and canopy architecture are the important traits in cereals imparting competitive ability against weed.

It was established fact that heavy weed infestation, particularly during the critical period of crop-weed competition (CP of CWC) i.e. 30-50 DAS, negatively influences growth and yield of wheat, and this fact was well visualized in NM treatment, where weed infestation during CP of CWC drastic reduced plant dry weight, LAI and biological yield.

Khan (2002) also observed that weed competition beyond 42 days, i.e. up to 56 days or longer, significant reduced wheat yield. Similarly, Chaudhary *et al.*, (2008) recorded highest grain yield when weeds were removed after 30 days followed by 40 days and 50 days after sowing .

PSM and MSM produced higher BY*d* as compared to SDM and NM treatments, the reasons for increased BY*d* could be attributed to two reasons: firstly, application of straw mulches buffers the soil temperature (Acharya *et al*., 2005) and helps in conservation of moisture (Araya and Stroosnijde, 2010), this will help in increased germination of wheat seedlings as compared to NM treatment, secondly, there was reduced germination of weeds under PSM might be due to rice residues contains eight phenolic acids, including cinnamic acid, salicylic acid, vanillic acid, p-hydroxybenzoic acid, 2,5-dihydroxybenzoic acid, ferulic acid, o-coumaric acid and p-coumaric acid (El-Shahawy *et al*., 2006). These phenolic acids considered as the key factor of rice allelopathy against suppressing a wide range of mono and dicotyledonous weeds in different crops. Chung *et al*. (2001) also reported allelopathic effect of rice residue on barnyard grass. Both these conditions provides favorable environment for acquisition of natural resources by crop plants thus resulted in increased number of grain/earhead, BY*d* and HI of wheat. Singh and Saini (2008) also observed weed suppression and positive effect on plant growth with PSM application. Further, application of MSM produced almost similar results to that of PSM in most of the parameters related to weed suppression and growth and yield attributes of wheat. In fact, researches reveal that positively influence of MSM on weed suppression might be due to release of some allelochemicals, like benzoxazolinone, 5-chloro-6-methoxy-2-benzoxazolinone (Cl-MBOA), and 6-methoxy-2-benzoxazolinone (MBOA) (Kato-Noguchi (2000) during degradation of straw. These allelochemicals have potential to inhibit germination of crops (rice and pea seedling) and weeds (*Maranthus caudatus*, *Lepidium sativum*, *Lactuca sativa*, *Digitaria sanguinalis*, *Phleum pretense, Lolium multiflorum*) (Kato-Noguchi, 2000), but in the later stages crop can easily overcome these allelopathic responses. Allelopathic inhibition of weeds germinations might be one of the key reasons for reduced weed growth in our experiment. Borghi *et al*. (2008) also reported reduced weed growth with application of maize straw. Moreover, reasons for lower grain/per earhead yield under maize straw mulch may be due to poor partitioning of photosynthate from vegetative to reproductive organs results in reduced number of grain/earhead.

Conclusion

On the basis of this investigation it was concluded that varietal selection and application of mulch has ample potential for weed management in wheat. Furthermore, under the late sown condition of eastern Uttar Pradesh, wheat variety DBW-39 was found highly effective for suppression of weed growth, particularly during critical crop-weed competition period and recorded higher number of grain/earhead, biological yield and harvest index followed by K-0307. Application of paddy straw 6 t/ha mulch and maize straw 6 t/ha mulch was found better which not only increased biological yield and HI of wheat but also reduced the growth of different weeds. This research further implicated that adoption of above-said varieties and mulch material provide low cost, technological feasible option, especially for small and marginal farmers of Indo-Gangetic plain, to manage the weeds and boost production and productivity of wheat.

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