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Integrated Effect of Seed Rates and Weed Management Treatments in Wheat (*Triticum aestivum* L.)

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Abstract: Increased crop density and use of herbicides are two important components of integrated weed management program in wheat but no much information is available on combined effects of these two treatments. A field experiment was conducted to determine the interaction effect of increasing seed rates and weed management treatments on monocot and dicot weeds, grain and straw yield and uptake of N, P and K by weeds in wheat (*Triticum aestivum* L.). Eighteen treatment combinations comprising three seed rates (S_1: 120; S_2: 160; and S_3: 180 kg ha^{-1}) and six weed management treatments {W_1: 2,4-D post-emergence (POST); W_2: pendimethalin, pre-emergence (PRE); W_3: pendimethalin (PRE) + 2,4-D (POST); W_4: pendimethalin (PRE) + hand weeding (HW); W_5: HW at 30 and 45 days after sowing (DAS); and W_6: control} were studied. Results indicate that among three seed rates, S_3 (180 kg/ha) recorded lowest weed counts as well as significantly the lowest weed biomass with 60.75% weed control efficiency (WCE). Among weed management treatments, PRE application of pendimethalin at the rate of 0.90 kg ha^{-1} recorded least number of weeds and higher yield. Interaction effect of seed rates and weed management treatments revealed that treatment combinations S_2xW_2 and S_3xW_2 recorded lowest weeds. Treatment combinations S_3xW_2 at 45 DAS and S_3xW_5 at harvest were found to be superior with respect to total weed biomass (33.40 kg ha^{-1}). Treatment combination S_3xW_2 recorded significantly higher grain yield (5470 kg ha^{-1}) and statistically this was at par with S_3xW_5. Uptake of N, P and K by weed was highest and lowest under treatment combinations S_1xW_6 (26.53, 15.36, 40.35 kg ha^{-1}) and S_3xW_2 (5.70, 3.00, 9.40 kg ha^{-1}), respectively.

Key words: seed rate, herbicide, nutrient uptake, weed management, wheat

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops and global wheat production is projected to grow by 11% to reach 688 million tonnes in 2014[13]. India is the second largest producer of wheat with an annual production of about 75 to 80 million tonnes. However, the average productivity of wheat in India is low (about 2624 kg ha^{-1})[1].

Among the various factors responsible for such a low productivity, weed is one of the major constraints explaining low wheat yield. Weeds compete with the crop plants for moisture, nutrients, light and space[19]. The critical period of crop-weed competition for wheat is 30-45 days after sowing [21]. Severe crop-weed competition results in wheat yield reduction to the extent of 18-73% in India[12]. Manual (removal of weed manually by labor) and physical methods of weed control (by using tractor drawn implements) are very effective in India, however, they have certain limitations like unavailability of labors during peak period under intensive farming, high labor cost; regeneration of weeds which require frequent operation. This has created an alternate scope for using herbicides and they are becoming more and more popular in developing countries including India. Several pre and post emergence herbicides have been registered and commercially available for controlling grass and broadleaved weeds in wheat in India. However, because of a change in weed flora and unsatisfactory control of broadleaved weeds, farmers are using PRE and POST herbicides. Weed management systems that depends heavily on herbicides are now accepted as unsustainable and it has also created a problem of

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ground water contamination and evolution of herbicide resistant weeds[19]. So, development of more comprehensive and sustainable weed management system is required for economic production of wheat. In wheat, a considerable variation is prevailing in seed rate used in different parts of India ranges from 35 to 140 kg ha^{-1} depending on varying seed size, time and method of sowing. 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. The weed suppression by increased crop density and spatial uniformity in wheat is recently documented[14,15]. However,[8] revealed that by using double seed rates did not increase wheat yield when herbicide was not used for controlling wild oat. When herbicide was not applied in lentil (*Lens culinaris*) and seed rate was increased to 1.5 times, resulted in 70% weed control compared with 90% when seeding rate was not increased and herbicides were used[3]. Thus, an integrated weed management treatment that increases crop competitiveness by increasing seed rate in combination with reduced herbicide rate might be an appropriate strategy.

Literature on combined effect of weed management treatment and seed rate is not well documented. Considering the importance of wheat among the winter cereals in western India, an attempt was made to study the sole and dual effect of seed rates and weed management treatments on control of weeds and yield of wheat (*Triticum aestivum* L.) cv. GW-496 in sandy loam soil under irrigated conditions of middle Gujarat, India. This information is important to know the potential role of seed rates in combination with various weed management treatments for development of an integrated approach for controlling weeds in wheat.

MATERIALS AND METHODS

Field Experiment Site: Field experiment was laid out in a factorial randomized complete block design (FRBD) at Agronomy Farm, Anand Agricultural University, Gujarat, India (Anand is located in middle Gujarat, a middle-west India state) in 2001-02. The venue records for 22° 35’ North latitude, 72° 55’ East longitude and 45.11 m elevation from the mean sea level, geographically. The region represents semi-arid and sub-tropical with hot summer and cool winter. The soil at the experimental site was sandy loam in nature with pH 7.5, 0.34% organic carbon, low in total nitrogen (0.041%), medium in phosphorus (50.88 kg ha^{-1}) and high in potassium (315.90 kg ha^{-1}). It is alluvial in origin, deep well drained and has fairly good moisture holding capacity.

Treatment Details: Treatments comprising three different seed rates (S_1: 120 $kgha^{-1}$, S_2: 160 kg ha^{-1}, S_3: 180 kg ha^{-1}) and six weed management treatments [W_1: 2,4-D at 0.50 kg ha^{-1} at 30 DAS, W_2: pre-emergence (PRE) application of pendimethalin at 0.90 kg ha^{-1}, W_3: PRE application of pendimethalin at 0.45 kg ha^{-1} + 2,4-D at 0.50 kg ha^{-1} at 30 DAS, W_4: PRE application of pendimethalin at 0.45 kg ha^{-1} + hand weeding at 30 DAS; W_5: weed free (two hand weedings at 30 and 45 DAS) and W_6: control (no weed management)], were replicated four times. The seeding was done in Oct. 2001 and crop was harvested in March, 2002. The fertilizers were incorporated as per the standard recommended rates. Irrigation was given five times during the crop season by surface channel method. Weed count of monocot, dicot and total weeds were taken randomly from 0.25 m^2 quadrates from net plot area from different three spots at 30, 45 DAS and at harvest and converted into m^2 area. Dry weight of weed was recorded after oven-drying at 60 C for 72 hrs. Weed control efficiency (WCE) was calculated by using formula suggested by [11].

$$WCE = \frac{DWC - DWT}{DWC} \times 100$$

Where:

- WCE = weed control efficiency;
- DWC = dry weight of weeds from control plots (weedy check); and
- DWT = dry weight of weeds in treated plots.

Chemical Analysis: Representative samples of crop and weeds collected from each net plot at the time of harvest were used for chemical analysis (N, P, K analysis). Oven-dried samples were powdered separately in a wiley mill for analysis of N, P and K content by standard methods. Plant materials were digested in a mixture of concentrated HNO_3, H_2SO_4 and 60% $HCLO_4$ in a ratio of 10:4:1[18]. Estimation of total nitrogen was made by modified Kjendahl’s method, phosphorus by Olsen’s method and potash by flame photometric method as described by[6]. The nutrient uptake by weed was calculated by following formula,

$$\text{Nutrient uptake by weed (kg ha}^{-1}\text{)} = \frac{\text{\% nutrient content X weed biomass at harvest (kg ha}^{-1}\text{)}}{100}$$

Harvesting of crop was done in March, 2002. Grain and straw yields were calculated from each net plot area and then data was converted to kg ha^{-1}.

Statistical Analysis: Arc sin square root transformation was used to normalize the treatment means prior to analysis of variance for the data of weed counts (at 30, 45 DAS and at harvest) as mentioned in table 1. The analysis of variance (ANOVA) was carried out on transformed data to test for differences among treatments at the 5% level of significance ($P<0.05$) by using factorial randomized complete block design (FRBD) statistical analysis package[4]. The significance and non-significance of a given variance was determined by calculating the S.Em.± and CD values. The coefficient of variation (CV%) was also calculated by standard formula.

RESULTS AND DISCUSSION

Effect of Seed Rates (S): Increasing seed rates from 120 to 180 kg ha^{-1} decreased weed count m^{-2} and weed biomass (Table 1 & 3). Monocot, dicot and total weeds m^{-2} were lowest for 180 kg ha^{-1} (S_3) at 30, 45 DAS and at harvest with maximum weed control efficiency (60.75%, Table 1 & 3). Decrease in weed population and weed dry weight with higher seed rate might be due to competition from crop plants for space, nutrients, moisture and solar radiation. The highest weeds were recorded in low seed rate treatment. At relatively low seed rate, crop density would be naturally less, leaving a large amount of resources available for weeds and enabling them to establish quickly. Similar trend of reducing weed density with increasing seed rates was observed by[24] in wheat. Seed rates of 160 and 180 kg ha^{-1} produced significantly higher grain yield (4974 & 5051 kg ha^{-1}, respectively) and straw yields i.e. 7165 & 7274 kg ha^{-1}, respectively (Table 5). Higher yield with higher seed rate was also reported by[22].

This implies that increased crop density had strong and consistent negative effects on weed biomass and positive effects on grain and straw yield. Crop-weed competition is influenced by the resource availability like mineral nutrient status of soil and the information on absorption of major nutrients by weeds might be an important tool in application of fertilizers[7]. Significantly the highest and lowest uptake of N, P, and K by weeds was recorded with seed rate 120 kg ha^{-1} (S_1) and 180 kg ha^{-1} (S_3), respectively (Table 7). The lowest uptake of these nutrients by weeds was associated with the lowest dry weight of weeds under higher seed rate. For crop-weed competition, the mineral nutrient level of the soil is important for managing the fertilizer applications in both time and space[9].

Effect of Weed Management Treatments (W): Effective control of weeds through different weed control treatments reduced weed populations considerably. Control of monocot, dicot and total weeds m^{-2} was observed at all intervals (30, 40 DAS and at harvest) under treatments W_2, W_3 and W_4. Neither monocot nor broadleaved weeds were observed at 30 DAS in these treatments (Table 1). This was reflected in reduced weed biomass by these treatments at 45 DAS and at harvest (Table 3). This might be because pendimethalin is a member of dinitroaniline group and it has been extensively used for controlling broadleaf weeds and grasses in agronomic and horticultural crops worldwide[5]. The primary mode of action of pendimethalin is by inhibition of cell mitosis[20] that inhibits polymerization of tubulin, the major protein constituent of microtubules[10].

Results are substantiated with the report of[17]. Pendimethalin at 0.90 kg ha^{-1} applied as a pre-emergence (W_2) recorded the highest grain yield (5224 kg ha^{-1}), followed by weed-free treatment (W_5), whereas highest straw yield was recorded under treatment W_5 (Table 5). The similar results were reported by[16]. There was no any crop injury observed in any herbicidal treatment. The lowest uptake of N by weeds at harvest was observed in the weed management treatment when weeds were removed manually at 30 and 45 DAS (W_5) and this result was statistically non-significant with treatments W_2 and W_4 (Table 7). The lowest uptake of P_2O_5 and K_2O (3.32 and 10.63 kg ha^{-1}, respectively for P_2O_5 and K_2O) was recorded when pendimethalin was applied as a pre-emergence at 0.90 kg ha^{-1} which was found to be non-significant with W_5 treatment (Table 7). The results also revealed that a single dose of pendimethalin at a higher rate (0.9 kg ha^{-1}) was better than a tank mix of pendimethalin (0.45 kg ha^{-1}) 2,4-D (0.50 kg ha^{-1}).

Interaction Effect of Seed Rates and Weed Management Treatments (SXW): Interaction effect of various seed rates and weed management treatments in wheat was significant for monocot, dicot and total weed counts (Table 2); weed biomass (Table 4); grain and straw yield (Table 6) and uptake of N, P_2O_5 and K_2O by weeds (Table 8). Significantly lower monocot, dicot and total weed counts m^{-2} and weed dry weights were recorded with treatment combinations S_3xW_2 at all intervals (Table 2 & 4). The pre-emergence soil application of selective herbicide pendimethalin might have reduced weed population during the initial stage and then the early size advantage of the crop is the theoretical basis for positive effects of increasing seed rates. But the application of 2,4-D at 30 DAS (W_3) was not effective even at higher seed rates. This might be because when weeds are taller than wheat in the early growing season, size-asymmetric competition might have given advantage to the weeds.

Table 1: Monocot, dicot and total weed counts m^{-2} recorded at 30, 45 DAS and at harvest as influenced by different seed rates and weed management treatments (Öx + 1 transformed values*.

Treat.	Weed count/m^2 at 30 DAS			Weed count/m^2 at 45 DAS			Weed count/m^2 at harvest		
	Monocot	Dicot	Total	Monocot	Dicot	Total	Monocot	Dicot	Total
Seed rate (S)									
S_1	6.14	10.63	16.77	6.14	7.99	14.13	7.96	10.77	18.73
	(26.37)	(92.70)	(119.07)	(26.37)	(48.83)	(75.20)	(48.50)	(95.52)	(144.42)
S_2	5.49	9.99	15.48	5.46	7.37	12.83	7.34	9.94	17.28
	(20.20)	(80.75)	(100.95)	(19.92)	(40.54)	(60.46)	(40.25)	(79.92)	(120.17)
S_3	5.22	9.94	15.16	5.33	7.20	12.53	7.17	9.69	16.86
	(17.79)	(80.00)	(80.00)	(18.75)	(38.50)	(57.25)	(38.04)	(75.50)	(113.54)
S.Em.±	0.04	0.04	0.04	0.07	0.07	0.07	0.06	0.05	0.05
C.D. 5%	0.10	0.12	0.12	0.20	0.20	0.19	0.016	0.15	0.15
Weed management treatments (W)									
W_1	7.67	14.16	21.83	8.14	5.88	14.02	8.88	9.76	18.64
	(44.50)	(173.17)	(217.67)	(50.92)	(23.83)	(74.75)	(62.17)	(76.75)	(138.92)
W_2	1.00	1.00	2.00	2.47	4.00	6.47	6.11	6.87	12.98
	(0.00)	(0.00)	(0.00)	(2.17)	(9.00)	(11.17)	(26.08)	(34.50)	(60.58)
W_3	1.00	1.00	2.00	3.04	4.51	7.55	6.57	8.13	14.7
	(0.00)	(0.00)	(0.00)	(4.17)	(12.33	(16.50)	(31.00)	(50.83)	(81.83)
W_4	1.00	1.00	2.00	2.92	4.62	7.74	6.37	7.79	14.16
	(0.00)	(0.00)	(0.00)	(3.67)	(13.08)	(16.75)	(28.83)	(46.08)	(74.91)
W_5	7.38	13.71	21.09	3.43	4.49	7.92	8.59	7.52	16.11
	(40.75)	(161.66)	(202.41)	(5.91)	(12.17)	(18.08)	(57.67)	(42.50)	(70.71)
W_6	7.60	14.12	14.68	8.95	14.61	23.56	9.82	16.87	26.69
	(43.50)	(172.08)	(215.58)	(63.25)	(185.33)	(248.58)	(77.83)	(252.0)	(329.83)
S. Em.±	0.05	0.06	0.06	0.10	0.10	0.09	0.08	0.08	0.07
C.D. 5%	0.15	0.17	0.17	0.29	0.29	0.26	(0.22)	0.22	0.21
(S x W)	Signi.	Signi.	Signi.	Signi.	Signi.	Signi.	Signi.	Singi.	Signi.
C.V. %	9.73	10.90	13.70	18.87	11.46	14.77	14.25	10.10	12.40

*figures in parenthesis indicate original values.

Table 2: Total weed counts m^{-2} at 30, 45 DAS and at harvest as influenced by the interaction effect of seed rates and weed management treatments (Öx + 1 transformed values)*.

Seed rates (S)	Weed management treatments (W)					
	W_1	W_2	W_3	W_4	W_5	W_6
Weed count /m^2 at 30 DAS						
S_1	16.36	1.00	1.00	1.00	16.08	16.84
	(236.00)	(0.00)	(0.00)	(0.00)	(227.50)	(251.00)
S_2	15.33	1.00	1.00	1.00	15.02	15.28
	(205.25)	(0.00)	(0.00)	(0.00)	(196.50)	(204.00)
S_3	15.55	1.00	1.00	1.00	14.55	14.85
	(211.75)	(0.00)	(0.00)	(0.00)	(183.57)	(191.75)
S. Em. ±0.10			C.D. 5%0.30		C.V. %13.70	
Weed count / m^2 at 45 DAS						
S_1	10.67	4.87	5.21	5.74	5.74	17.78
	(93.50)	(15.00)	(17.75)	(22.50)	(22.50)	(281.50)
S_2	9.29	4.16	4.71	4.87	5.33	16.38
	(68.75)	(10.00)	(13.75)	(15.00)	(18.75)	(236.50)
S_3	8.87	3.92	5.24	4.77	4.61	16.09
	(62.00)	(8.50)	(18.00)	(14.25)	(13.00)	(227.75)
S. Em. ±0.16			C.D. 5%0.46		C.V. %14.77	
Weed count / m^2 at harvest						
S_1	13.96	9.44	10.47	10.08	9.87	20.40
	(168.00)	(71.25)	(89.75)	(82.50)	(78.75)	(376.25)
S_2	12.32	8.52	9.94	9.49	9.17	18.82
	(128.25)	(56.50)	(80.00)	(72.00)	(66.75)	(317.50)
S_3	13.27	8.35	9.70	9.38	9.06	18.20
	(150.50)	(54.00)	(75.75)	(70.25)	(65.00)	(295.75)
S. Em. ±0.13			C.D. 5%0.36		C.V. %12.40	

* Figures in parenthesis indicate original values

Table 3: Dry weight of total weeds (kg ha^{-1}) at 45 DAS and at harvest and weed control efficiency as influenced by different seed rates and weed management treatments

Treatment	Dry weight of total weeds (kg ha^{-1}) At 45 DAS	At harvest	WCE (%)
	Seed rates (S)		
S_1	172.24	445.75	47.83
S_2	108.39	364.52	57.34
S_3	88.78	335.57	60.75
S.Em.±	4.71	4.48	-
C.D. 5%	13.38	12.73	-
	Weed management treatments (W)		
W_1	127.59	352.87	58.70
W_2	39.03	262.10	69.32
W_3	43.40	288.29	66.26
W_4	41.03	276.14	67.68
W_5	38.57	257.47	69.87
W_6	449.19	854.44	-
S.Em.±	6.66	6.33	-
C.D. 5%	18.92	18.00	-
(S x W)	Signi.	Signi	-
C.V. %	18.73	9.75	-

DAS = Days after sowing; WCE= Weed control efficiency

Table 4: Dry weight of total weeds (kg ha^{-1}) at 45 DAS and at harvest influenced by interaction effect of seed rates and weed management treatments.

Seed rates (S)	Weed management treatments (W) W_1	W_2	W_3	W_4	W_5	W_6
	Dry weight of weeds (kg ha^{-1}) at 45 DAS					
S_1	157.82	47.49	49.10	47.20	45.40	686.41
S_2	121.44	36.20	41.00	37.50	35.20	379.00
S_3	130.51	33.40	40.10	38.40	35.10	282.17
S. Em. ±11.53		C.D. 5%32.77			C.V. %18.73	
	Dry weight of weeds (kg ha^{-1}) at harvest					
S_1	408.50	300.20	340.00	319.50	282.00	1024.32
S_2	340.40	250.70	272.55	265.30	256.70	801.50
S_3	309.70	235.40	252.32	243.62	233.70	737.50
S. Em. ±10.97		CD (5%)31.18			C.V. %9.75	

Maximum grain and straw yield of wheat were recorded under the maximum seed rate of 180 kg ha^{-1} along with PRE application of pendimethalin at the rate of 0.90 kg ha^{-1} (S_3xW_2), (i.e. 5470 and 7452 kg ha^{-1} respectively for grain and straw yield) (Table 6). This result was in conformity with complete control of grass weeds as well as an acceptable level of broadleaved weed control provided by pendimethalin. Furthermore, efficacy of pendimethalin when applied as PRE and 2,4-D in combination with any seed rate was not as efficient as when applied alone with higher seed rates. This might be because the lower dose of pendimetalin and 2,4-D might not be enough for controlling broadleaved weeds and some thick stand of grass weeds. Contrary to this, the lowest value of grain yield of wheat was recorded under seed rate of 120 kg ha^{-1} with control, where there was no any attempt made for controlling weeds. The findings are in accordance with those reported by[2], and[23]. Significantly lower uptake of nutrients was recorded under seed rate 180 kg ha^{-1} along with weed management treatments W_2, W_4 and W_5 (Table 8). This was mainly due to significantly less dry matter accumulation of weeds under these treatment combinations. There was no significant

Table 5: Grain and straw yields (kg ha^{-1}) of wheat influenced by different seed rates and weed management treatments.

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
	Seed rates (S)	
S_1	4541	6795
S_2	4974	7165
S_3	5051	7274
S.Em.±	10.72	9.86
CD (5%)	30.48	28.04
	Weed management treatments (W)	
W_1	4770	7235
W_2	5224	7298
W_3	4987	7281
W_4	5009	7353
W_5	5132	7417
W_6	4011	5884
S.Em.±	15.16	13.95
C.D. (5%)	43.10	39.66
(S x W)	Signi.	Signi.
CV %	14.08	9.68

Table 6: Grain and straw yields (kg ha^{-1}) of wheat influenced by interaction effect of seed rates and weed management treatments.

Seed rates (S)	Weed management treatments (W)					
	W_1	W_2	W_3	W_4	W_5	W_6
			Grain yield (kg ha^{-1})			
S_1	4433	4850	4670	4730	4793	3770
S_2	4882	5352	5070	5100	5260	4183
S_3	4994	5470	5221	5197	5344	4080
S. Em. ± : 26.26			C.D. (5%) : 74.65		C.V. % : 14.08	
			Straw yield (kg ha^{-1})			
S_1	7140	7073	7041	7147	7263	51.07
S_2	7252	7369	7333	7420	7455	6162
S_3	7314	7452	7470	7492	7534	6382
S. Em. ± : 24.16			CD (5%) : 68.89		CV % : 9.68	

Table 7: Content of nitrogen, phosphorus and potash (kg ha^{-1}) by weed at harvest.

Treatment	Content (kg ha^{-1}) by weed		
	Nitrogen	Phosphorus	Potash
		Seed rates (S)	
S_1	11.21	6.14	18.12
S_2	8.95	4.79	14.94
S_3	8.06	4.58	13.43
S.Em.±	0.16	0.12	0.18
C.D. (5%)	0.46	0.34	0.51
		Weed management treatmentss (W)	
W_1	8.69	4.40	14.09
W_2	6.62	3.32	10.63
W_3	7.36	4.12	12.56
W_4	6.97	3.88	11.91
W_5	6.27	3.52	11.09
W_6	20.54	11.78	32.69
S.Em.±	0.23	0.17	0.25
C.D. (5%)	0.65	0.49	0.72
(S x W)	Signi.	Signi.	Signi.
CV %	14.41	11.46	19.70

Table 8: Uptake of nitrogen, phosphorus and potash (kg ha^{-1}) by weeds at harvest as influenced by an interaction of seeding rates and weed management treatments.

Seed rate (S)	Uptake of nutrients by weeds (kg ha^{-1})					
	W_1	W_2	W_3	W_4	W_5	W_6
			Nitrogen			
S_1	10.65	7.63	7.95	7.80	6.70	26.53
S_2	8.09	6.53	7.30	7.00	6.22	18.28
S_3	7.32	5.70	6.83	6.12	5.90	16.52
S. Em. ± : 0.40			C.D. (5%) : 1.12		C.V. % : 14.41	
			Phosphorus			
S_1	4.89	3.82	4.50	4.27	4.00	15.36
S_2	4.20	3.13	3.98	3.72	3.30	10.41
S_3	4.10	3.00	3.89	3.65	3.25	9.58
S. Em. ± : 0.30			C.D. (5%) : 0.84		C.V. % : 11.46	
			Potash			
S_1	16.32	12.25	13.90	13.20	12.70	40.35
S_2	13.60	10.23	12.34	11.79	10.84	30.84
S_3	12.36	9.40	11.45	10.74	9.73	26.89
S. Em. ± : 0.13			C.D. (5%) : 0.36		C.V. % : 12.40	

interaction observed between crop density and nitrogen fertilizer addition on weed biomass but herbicide treated plots had much higher yields than weed infested plots[7].

Conclusion: In this project, we attempt to study the individual and interaction effect of seed rates and various weed management treatments to control weeds in wheat under irrigated conditions of middle Gujarat, India. In light of the result obtained, it is concluded that wheat crop sown at the seed rate of 180 kg ha^{-1} and application of pendimethalin at the rate of 0.90 kg ha^{-1} as pre-emergence or along with hand weeding twice at 30 and 45 DAS seems to be effective for controlling weeds and securing maximum yields. Thus, result indicates that increased weed suppression through the combination of increased crop density and reduced rate and number of herbicide would result in increased crop and straw yield. Such an integrated strategy will offer environmentally friendly alternative to physical weed control in crops, reducing requirement of labors and fuel consumption. However, we suggest that a multi year and multi location experiments are required in different soil types to confirm the results obtained in this study.

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