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Impact of Seed Bed Manipulations and Weed Management Practices on Growth, Yield and Economics of Wheat under Organic Conditions

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A B S T R A C T

A field experiment was conducted during *rabi* 2015-16 to study the influence of seed bed manipulations and weed management practices on growth, yield and economics of wheat under organic conditions at Model Organic Farm of CSKHPKV, Palampur. Results revealed that standard seed bed recorded 6.73 and 12.46 per cent higher wheat yield and net returns, respectively over stale seed bed. Gram intercropping + one manual hoeing resulted in significantly taller plants at 120 days after sowing whereas, two manual hoeings recorded significantly highest dry matter accumulation and number of shoots per square meter at 90 days after sowing which resulted in significant increase in grain and straw yield (3796 kg/ha and 7144 kg/ha) of wheat. In terms of economics, two manual hoeings recorded highest net returns (Rs. 84,064/ha) and remained statistically at par with gram intercropping + one manual hoeing (Rs. 80,941/ha). Both natural farming (gram intercropping + mulching) and natural farming (mulching) treatments recorded significantly highest net returns of 3.32 and 3.10 per rupee invested, respectively. In addition, inclusion of legume as intercrop in treatments comprised of gram intercropping helped in increasing the nitrogen status of the soil than treatments comprised of sole stand of wheat.

Introduction

Wheat (*Triticum aestivum L.*) is one of the most important grain crops grown in approximately 225 million ha worldwide and India is the second largest producer of wheat in the world contributing about 93.50 million tonnes of grains with productivity of 3.0 t/ha from the area of 30.23 million hectares (Anonymous, 2016). Wheat is a versatile crop, growing across a range of agro-ecological zones and gets infested with variety of weeds which can cause yield losses to the extent of 50 per cent (Azad, 2003). Herbicide used to be a key component in weed management, but their indiscriminate use has resulted in serious ecological and environment problems. A strong need was felt to discover the alternative weed management options n organic agriculture (Economou *et al.*, 2002).

Different cultural and mechanical practices can provide a sigh of relief for the growers with no chemical application in agriculture.

'Daab' or delayed sowing, also known as the stale seed bed technique delay final seedbed preparation in order to stimulate as much as possible the emergence of weeds prior to sowing and is very effective in decreasing the weed seed reserve in soil (Rasmussen, 2004). Manual hand weeding remains a very safe and effective method against most weeds in most crops as it provides clean and thorough weeding. However manual weeding is becoming less common because of non-availability of labour at critical times and increased labour cost.

Intercropping is an advanced agronomic technique that allows two or more crops to yield from the same area of land, better utilization of resources, reduce weed competition and minimize the risk of food shortages by enhancing yield stability (Aziz *et al.,* 2015). Whereas, mulching of soil surface reduce weed population by suppressing the growth of emerging weed seedlings (Datta *et al.,* 2017).

Due to negative effects of herbicides and increasing demand of organic products there is dire need to find out eco-friendly techniques of weed management especially in organic wheat production system. Hence, a comprehensive study was undertaken to keep the weeds below threshold level and assess the impact of seed bed manipulations and weed management practices on growth, yield and economics of wheat under organic conditions.

Materials and Methods

The experiment was conducted during *rabi* season of 2015-16 at the Model Organic Farm of Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur (India) situated at 32°4´ N latitude and 76°3´ E longitude at an elevation of about 1224 meters above mean sea level in north-western Himalayas. The soil of the experimental field was silty clay loam in texture, acidic in reaction (pH 5.3), low in available nitrogen (205 kg/ha), high in available phosphorus (32 kg/ha) and medium in available potassium (190 kg/ha). Experiment was laid out in split plot design with three replications comprising of seed bed manipulations (standard and stale seed bed) in main plots and seven weed management practices [one manual hoeing, two manual hoeings, gram intercropping (no weeding), gram intercropping + one manual hoeing, natural farming (mulching), natural farming (gram intercropping + mulching) and weedy check] in sub plots.

Wheat variety HPW 155 was sown on 6th November, 2015 under standard seed bed and on 7th December, 2015 under stale seed bed following all organic packages of practices except the natural farming treatments. In natural farming treatments, weeds were cut with sickle and left on surface and used as mulch. Weed population was recorded at 90 and 120 days after sowing using 50 cm x 50 cm quadrate. Data on weed count have shown high degree of variation and hence were subjected to square root $\sqrt{(x + 0.5)}$ transformation. The growth parameters were recorded at monthly interval of crop growth period. The crop was harvested treatment wise at maturity and grain yield per hectare was computed. Economics of different treatments was calculated taking into account of the prevailing market prices of organic inputs and output.

Soil samples were collected after the harvest of wheat crop and analyzed for different parameters like pH, organic carbon, available nitrogen, phosphorus and potassium content by following the standard methods to study the changes in the soil fertility levels. The data recorded on various aspects in the present study was subjected to the statistical analysis using analysis of variance as per procedure suggested by Gomez and Gomez (1984).

Results and Discussion

The major weed flora of the experimental plots consisted of *Phalaris minor* Retz., *Avena fatua* L., *Lolium temulentum* L., *Poa annua* L. and *Briza minor* L. among grasses; *Anagallis arvensis* L., *Vicia sativa* L., *Coronopus didymus* L. and *Trifolium* sp. among broad leaf weeds. Grasses were found to be the predominant category followed by broad leaved weeds.

Effect on weed density

The data presented in Table 1 on weed density revealed that stale seed bed resulted in significantly lower density of total weeds at 90 and 120 days after sowing over standard seed bed. This might be due to early weed seed germination in stale seed preparation later on shallow ploughing which destroyed germinated weed flora. Similar were the observations of Pandey *et al.,* (2009). Among different weed management treatments, two manual hoeings being at par with and gram intercropping + one manual hoeing registered lowest density of total weeds at 90 and 120 days after sowing. This was due to the fact that manual hoeings resulted in uprooting and mortality of weeds during early growth stages of the crop and gram intercropping lowered the availability of environmental resources for weeds use. These results are in direct conformity with the findings of Nadeem *et al.,* (2006) and Eskandari (2011).

Effect on crop growth

A perusal of the data in Table 2 revealed that seed bed manipulations and weed management treatments significantly influenced plant height at 120 days after sowing, dry matter accumulation and number of shoots per square meter at 90 days after sowing. Standard seed bed recorded significantly higher plant height, dry matter accumulation and number of shoots per square meter over stale seed bed. The possible cause for decrease in growth parameters under stale seed bed was due to delay in sowing to control weeds and decrease in temperature as well as day length which shortened the vegetative growth period of wheat crop. Similar results were also reported by Razzaque and Rafiquzzaman (2006). However, both standard and stale seed bed could not exhibit significant influence on number of leaves at 90 days after sowing. Among weed management treatments, gram intercropping + one manual hoeing being at par with two manual hoeings resulted in significantly taller plants. Similarly, maximum plant height in plots where wheat was intercropped with chickpea has also been reported by Khan *et al.,* (2005). Two manual hoeings significantly increased dry matter accumulation and produced more number of shoots per square meter over other treatments. This might be due to more effectiveness of manual hoeings in reducing weed density which contributed to increase in dry matter accumulation and number of shoots per square meter of wheat crop. Similar results were obtained by Amare *et al.,* (2014). Gram intercropping + one manual hoeing produced significantly more number of leaves at 90 days after sowing. However, less plant population per square meter in replacement series in intercropping system recorded less value of dry matter accumulation and number of shoots per square meter of wheat crop.

Effect on crop development

Data pertaining to the days taken for attainment of different stages of wheat crop have been presented in Table 3. Among seed bed manipulations, standard seed bed took significantly more number of days to attain tillering, earing and maturity as compared to stale seed bed. This might be due to the fact that November planted wheat under standard seed bed had more time for vegetative growth,

so heading started 76-78 days after sowing, whereas this period reduced to 69-70 days in December sowing of wheat under stale seed bed. In case of December sowing, high temperature prevailing at grain filling stage caused forced maturity and reduction in days to maturity. Similar findings have been reported by Khokhar *et al.*, (2010). However, different treatments under weed management practices could not influence the number of days taken to attain tillering, earing and maturity.

Table.1 Effect of seed bed manipulations and weed management methods on total weed density

Treatments	Total weed density (No./m^2)	
	90 DAS	120 DAS
Seed bed manipulations		
Standard seed bed	15.98 (268.57)	18.17 (354.33)
Stale seed bed	14.06 (206.14)	15.65 (254.90)
CD (P=0.05)	0.69	0.66
Weed Management		
One Manual hoeing	13.73 (188.66)	15.27 (234.34)
Two Manual hoeings	11.47 (132.67)	13.50 (183.67)
Gram intercropping (no weeding)	14.20 (202.33)	15.81 (251.17)
Gram intercropping + one manual hoeing	12.11 (146.33)	14.05 (197.87)
Natural farming (Mulching)	16.10 (260.17)	17.92 (322.50)
Natural farming (Gram intercropping + mulching)	15.27 (233.84)	16.97 (288.66)
Weedy check	22.25 (497.51)	24.85 (621.84)
CD (P=0.05)	0.66	0.55

Table.2 Effect of seed bed manipulations and weed management methods on growth parameters of wheat

Treatments	Plant height (cm)	Dry matter accumulation (g/m^2)	Number of shoots ($No./m^2$)	Number of leaves per plant
	At 120 DAS	At 90 DAS		
Seed bed manipulations				
Standard seed bed	69.48	107.63	194.38	5.47
Stale seed bed	64.28	96.47	180.05	5.11
CD (P=0.05)	4.84	4.44	4.14	NS
Weed Management				
One Manual hoeing	71.30	123.95	231.00	5.71
Two Manual hoeings	73.10	131.47	236.17	5.93
Gram intercropping (no weeding)	67.31	89.84	166.17	5.12
Gram intercropping + one manual hoeing	76.64	102.48	183.17	6.08
Natural farming (Mulching)	60.06	100.00	178.67	4.71
Natural farming (Gram intercropping + mulching)	65.28	84.09	159.67	4.95
Weedy check	54.46	82.52	155.67	4.55
CD (P=0.05)	5.43	4.21	7.98	0.77

Table.3 Effect of seed bed manipulations and weed management methods on number of days taken for attainment of different growth stages in wheat

Treatments	Tillering	Earing	Maturity
Seed bed manipulations			
Standard seed bed	60	113	183
Stale seed bed	37	94	161
CD (P=0.05)	8	6	8
Weed Management			
One Manual hoeing	48	102	171
Two Manual hoeings	47	101	170
Gram intercropping (no weeding)	48	103	172
Gram intercropping + one manual hoeing	47	100	169
Natural farming (Mulching)	49	106	173
Natural farming (Gram intercropping + mulching)	49	105	173
Weedy check	51	106	175
CD (P=0.05)	NS	NS	NS

Table.4 Effect of seed bed manipulations and weed management methods on yield of wheat and gram

Treatments	Wheat Grain yield (kg/ha)	Wheat Straw yield (kg/ha)	Gram Seed yield (kg/ha)	Gram Straw yield (kg/ha)
Seed bed manipulations				
Standard seed bed	2711	5502	322	532
Stale seed bed	2540	5185	273	479
CD (P=0.05)	100	94	-	-
Weed Management				
One Manual hoeing	3430	6869	-	-
Two Manual hoeings	3796	7144	-	-
Gram intercropping (no weeding)	2292	4531	285	485
Gram intercropping + one manual hoeing	2771	5453	364	610
Natural farming (Mulching)	2382	4919	-	-
Natural farming (Gram intercropping + mulching)	1885	4325	243	422
Weedy check	1822	4163	-	-
CD (P=0.05)	132	115	-	-

Table.5 Effect of seed bed manipulations and weed management methods on soil properties after harvest of wheat crop

Treatments	pH	Organic carbon (%)	Available kg/ha		
			Nitrogen	Phosphorus	Potassium
Seed bed manipulations					
Standard seed bed	5.56	1.45	216.10	28.90	192.05
Stale seed bed	5.45	1.54	225.05	35.95	199.14
CD (P=0.05)	NS	NS	NS	NS	NS
Weed Management					
One Manual hoeing	5.58	1.46	215.67	34.00	199.17
Two Manual hoeings	5.42	1.54	229.50	37.83	203.33
Gram intercropping (no weeding)	5.38	1.58	234.33	32.50	192.83
Gram intercropping + one manual hoeing	5.32	1.62	242.83	35.33	201.50
Natural farming (Mulching)	5.65	1.39	210.33	31.67	193.50
Natural farming (Gram intercropping + mulching)	5.52	1.50	222.83	29.83	191.67
Weedy check	5.68	1.38	188.50	25.83	187.17
CD (P=0.05)	NS	NS	14.53	6.06	8.90
Initial status	5.30	1.33	205.02	32.24	190.23

Table.6 Effect of seed bed manipulations and weed management methods on economics of wheat

Treatments	Cost of cultivation (Rs./ha)	Gross returns (Rs./ha)	Net returns (Rs./ha)	Net returns per rupee invested
Seed bed manipulations				
Standard seed bed	29589	97571	67981	2.30
Stale seed bed	30286	90737	60451	2.01
CD (P=0.05)	-	4025	4025	NS
Weed Management				
One Manual hoeing	34369	109817	75449	2.20
Two Manual hoeings	34717	118781	84064	2.42
Gram intercropping (no weeding)	34174	94460	60287	1.77
Gram intercropping + one manual hoeing	34523	115463	80941	2.34
Natural farming (Mulching)	18809	77150	58342	3.10
Natural farming (Gram intercropping + mulching)	18957	81984	63027	3.32
Weedy check	34020	61424	27404	0.81
CD (P=0.05)	-	3331	3331	0.11

Effect on yield

A perusal of the data in Table 4 further revealed that standard seed bed significantly increased the grain and straw yield of wheat and gram crop over stale seed bed. The possible cause for decrease in yield under stale seed bed was due to delay in sowing to control weeds and reduction in growth parameters. In a study, Khokhar *et al.,* (2010) found that two weeks delay in sowing beyond November 15 resulted in 16 per cent reduction in grain yield. But in the present investigation, four weeks delay in sowing under stale seed bed reduced wheat grain yield only by 6.31 per cent over standard seed bed. This might be due to less weed pressure under stale seed bed which compensated the yield loss. Among weed management treatments, two manual hoeings produced significantly higher grain and straw yield of wheat as compared to other treatments. The higher grain yield of wheat in two manual hoeings might be due to lower cop-weed competition and weed density and higher plant density under sole cropping compared with intercropping combinations. The findings corroborated the results obtained by Sharma and Sharma (1998) and Kumar and Agarwal (2013). Weeds in weedy check reduced grain yield to the tune of 52.00 per cent over two manual hoeings. Similar findings were noticed by Singh *et al.,* (2015) who obtained 50.00 per cent wheat yield reduction in weedy check over weed free condition. However, gram intercropping + one manual hoeing produced higher seed and straw yield of gram over gram intercropping and natural farming (gram intercropping + mulching) treatments.

Effect on soil fertility

Data presented in Table 5 showed that seed bed manipulations and weed management treatments could not significantly influence

the soil pH and organic carbon. The effect of seed bed manipulations also could not influence the available nitrogen, phosphorus and potassium content in soil significantly. Among weed management treatments, gram intercropping + one manual hoeing being at par with gram intercropping significantly increased the available nitrogen content in soil over other treatments. This increase might be due to ability of leguminous crop to form symbiotic relationship with rhizobium and fix atmospheric nitrogen. Whereas, two manual hoeings recorded significantly highest available phosphorus and potassium content in soil. The low amount of available phosphorus and potassium content in soil under intercropping system might be because of legumes require more amount of available phosphorus and potassium for their growth and development. These results are in close conformity with the findings of Nyoki and Ndakidemi (2016) and Venkatesh *et al.*, (2010).

Effect on economics

It is evident from the data presented in Table 6 that maximum cost of cultivation (Rs. 30286/ha) was incurred under stale seed bed as compared to standard seed bed. However, standard seed bed recorded significantly higher gross returns (Rs. 97571/ha), net returns (Rs. 67981/ha) and net returns per rupee invested (2.30) over stale seed bed. Stale seed bed technique was expensive due to irrigation required to stimulate weed seed germination and shallow ploughing to destroy germinated weed flora whereas, standard seed bed was profitable due to low cost and higher grain and straw yield of wheat and gram crop.

Among weed management treatments, two manual hoeings recorded highest cost of cultivation (Rs. 34717/ha) due to high labour cost. Similar findings were reported by Singh and Saha (2000). But the high cost involved in two manual hoeings was compensated by the additional grain and straw yield of sole wheat crop. Therefore, two manual hoeings recorded higher net returns of Rs. 84,064/ha and was statistically at par with gram intercropping + one manual hoeing. Whereas, both natural farming (gram intercropping + mulching) and natural farming (mulching) treatments recorded significantly highest net returns of 3.32 and 3.10 per rupee invested, respectively. The higher net returns per rupee invested under natural farming treatments was mainly due to reduced cost of cultivation.

It is conclusively inferred that stale seed bed resulted in lower total weed density over standard seed bed but due to delay in sowing to control weeds standard seed bed recorded higher value of growth parameters, grain yield of wheat and net returns over stale seed bed. Two manual hoeings recorded highest dry matter accumulation, number of shoots per square meter and grain yield of wheat and remained statistically at par with gram intercropping + one manual in terms of plant height, number of leaves and net returns. The both treatments are best option for effective weed management in wheat under organic production system.

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