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Research Paper

Effect of tillage, organic manures and fertilizer doses on productivity, profitability and quality of wheat (*Triticum aestivum*) under mid-hill conditions of Himachal Pradesh

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ABSTRACT

A field experiment was conducted during the winter (*rabi*) season of 2015-16 and 2016-17 at Palampur, Himachal Pradesh, to study the effect of tillage, organic manures and fertilizer doses on wheat (*Triticum aestivum* L.). The experiment was laid out in split-plot design with 3 replications. There were 6 main-plots, consisting of combinations of 3 tillage (zero tillage, minimum tillage and conventional tillage) and 2 organic manures (vermicompost @ 5 t/ha and FYM @ 10 t/ha) treatments, and 3 subplots with 3 fertilizer doses (50, 75 and 100% recommended dose of fertilizers). Significantly higher values of effective tillers/m^2, ear length, filled grains/ear, 1,000-grain weight, grain, straw and biological yields, harvest index, gross and net returns, benefit: cost and profitability were recorded under conventional tillage followed by minimum tillage. Application of 100% followed by 75% recommended dose of fertilizers recorded significantly higher effective tillers/m^2, ear length, spikelets/ear, total number of grains, 1,000-grain weight, harvest index and protein content. The highest grain (2.7 t/ha), straw and biological yields, productivity (15.59 kg/ha/day) and gross returns (61.56 × 10^3 ₹/ha) were recorded with the application of vermicompost @ 5 t/ha. Application of recommended dose of fertilizers resulted in the highest grain (2.88 t/ha), straw and biological yields, gross returns (65.05 × 10^3₹/ha), net returns (26.28 × 10^3₹/ha), benefit: cost (1.65) and profitability (151.85₹/ha/day). Minimum tillage, vermicompost @ 5 t/ha and 100% recommended dose of fertilizers proved to be the best economical treatment for enhancing productivity, profitability and quality of wheat.

Key words: Fertilizer, Organic manures, Productivity, Profitability, Quality, Tillage, Wheat

Wheat is the most widely cultivated crop and India is the second largest producer of wheat in the world after China, with about 12% share in total world wheat production. It is cultivated on 30.2 million ha area with production of 95.4 million tonnes, with a productivity of 3,158 kg/ha (agricoop.nic.in, 2018). It is an important winter cereal crop in the state, occupying 364,200 ha area, with production of 608,600 tonnes and productivity of 1,671 kg/ha (Kumar *et al.,* 2015).

Tillage plays an important role in influencing crop growth, yield and crop micro-environment. Conservation tillage has its own advantages over conventional tillage. It improves various properties of soil. It adds organic matter, improves soil and water quality, increases infiltration, decreases run-off and pollution in addition to less soil disturbance and lesser erosion. It optimizes water-storage capacity in the soil profile. Protective tillage provides a good environment for growth and development of crop, thus resulting in increased wheat yield because of improved soil water and thermal status (Yang *et al.,* 2017). Minimum tillage with mulch decreases soil erosion in comparison to conventional tillage. In case of microbiological activity, a greater number of micro-organisms are found under conservation tillage than conventional because of lesser soil disturbance. No-tillage soils have been found with rhizobia isolates which fixed more atmospheric nitrogen than rhizobia under conventional tillage (Ferreira *et al*., 2000).

In the recent years, there is much concern about soil health, pollution and healthy food. The organic sources of nutrients supply micro-nutrients in addition to macro-nutrients to the crops. Organic sources like vermicompost

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and farm yard manure are environment friendly, rich in nutrients and enzymes, add organic matter into the soil and help conversion of waste into manures. They are also cost-effective and food grown through these manures are safe to eat. Continuous application of farm yard manure and green manure improves the soil fertility, soil health, adds organic matter, enhances micro-organisms, increases moisture-retention capacity of soil and also soil organic carbon content and photosynthetic rate (Biswas *et al*., 2014). However, it is impossible to meet out total nutrient requirement of a crop from organic manures due to their insufficient availability. Continuous application of only chemical fertilizers in the crops results in poor crop productivity, poor soil health and unsustainability. Reducing quantity of chemical fertilizers by applying organic manure in combination with fertilizers enhances productivity and profitability. Considering these facts, the present investigation was conducted to study the effect of tillage, organic manures and fertilizer doses on wheat under mid-hill conditions of Himachal Pradesh.

MATERIALS AND METHODS

The field experiment was conducted during the winter season of 2015–16 and 2016–17 at the experimental field situated at Research Farm of Department of Agronomy, Forages and Grassland Management, Chaudhary Sarvan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur (32°11´ N, 76° 32´ E, 1,290 m above mean sea-level). The soil was silty-clay loam and acidic in nature (*p*H 5.5). The soil was low in available N (216.56 kg/ha), medium in available P (17.08 kg/ha) and low in available K (231.44 kg/ha). In the first winter season of 2015–16, the weekly minimum and maximum temperature ranged from 1.8 to 17.0 °C and 14.4 to 31.0°C, respectively. In the second winter season of 2016–17, the mean weekly minimum and maximum temperature ranged from 1.7 to 19.0°C and 11.6 to 32.1°C, respectively. Total rainfall received was 271.8 mm and 351.4 mm during the first and second season of 2015–16 and 2016–17, respectively.

The experiment was laid out in split-plot design with 3 replications at a fixed location for 2 consecutive years. There were 6 main plots, consisting of 6 treatment combinations of 3 tillage (zero tillage, minimum tillage and conventional tillage) and 2 organic manures (vermicompost, 5 t/ha and FYM, 10 t/ha), and 3 subplots, consisting of 3 fertilizer doses (50, 75 and 100% recommended dose of fertilizers). 'HPW 236' was used as test variety, sown at 22.5 cm inter-row spacing on 21st November and 15th November in 2015–16 and 2016–17, respectively. Seeds were treated with Bavistin @ 2.5 g/kg seed before sowing of the seed for the protection of crop plants from seed-borne diseases. Farm yard manure (FYM) and vermicompost were applied as per treatment at the time of sowing. Recommended dose of N, P and K nutrients (120-60-30) was applied @ 50, 75 and 100% as per treatment. The N, P and K nutrients were applied through urea, single superphosphate and muriate of potash respectively. Isoproturon (75% WP) @ 1.0 kg/ha and 2, 4 - D (Sodium salt, 80%) 0.5 kg/ha + 750 litres water was sprayed at 35 days after sowing(DAS) to control weeds. In addition to chemical weed control, 1 hand weeding was also done 6 weeks after sowing during both the years. In zero tillage, Paraquat herbicide (0.6 litre/ha) was also sprayed a week before sowing of the crop to control weeds. Other package of practices recommended for the region were also followed. The mean values of all the recorded characters including yield attributes, yield, economics and protein were subjected to analysis of variance technique as applicable to split-plot design. The significance of the difference between the mean of the 2 treatments was estimated through least significant difference at 5% probability level.

RESULTS AND DISCUSSION

Yield attributes

The highest number of effective tillers/m^2 was recorded under conventional tillage, while the lowest was under zero tillage. The results confirm the findings of Nehra *et al.* (2001) and Ramesh *et al.* (2014). Vermicompost @ 5 t/ha resulted in higher number of effective tillers (2.71%) than farmyard manure @ 10 t/ha. Application of 100% followed by 75% recommended dose of fertilizers recorded significantly higher number of effective tillers (3.87%) than 50% recommended dose of fertilizers. This might be owing to adequate availability of nutrients resulted in vigorous growth and development of wheat. The longest ear length was recorded under conventional tillage, whereas the shortest was under zero tillage. Organic manures did not show any effect on ear length. However, vermicompost @ 5 t/ha recorded numerically longer ear than FYM @ 10 t/ha. Application of 100% followed by 75% recommended dose of fertilizers recorded significantly longer ear length (9.43%) than 50% recommended dose of fertilizers (Table 1). This may be owing to adequate availability of nutrients with higher fertilizer doses to the wheat plants resulted in longer ear length. Tillage practices did not influence number of spikelets/ear. However, numerically maximum number of spikelets/ear was recorded under conventional tillage, while minimum was under zero tillage. These findings are in corroboration with work of Mondal *et al.* (2018). Spikelets/ear remained unaffected due to different organic manures. Application of 100% followed by 75% recommended dose of fertilizers recorded significantly

higher number of spikelets/ear (8.03%) than 50% recommended dose of fertilizers. This might be owing to more availability of nutrients that resulted in better growth and thus there was higher number of spikelets/ear (Table 1).

No significant effect of tillage and organic manures was observed on total grains/ear. Application of 100% followed by 75% recommended dose of fertilizers resulted in significantly higher number of total grains/ear (8.01%) than 50% recommended dose of fertilizers. Conventional tillage recorded higher number of filled grains/ear (43.8%) than zero tillage. The lowest number of filled grains/ear was recorded under zero tillage. Organic manures did not affect filled grains/ear. The highest number of filled grains/ear was recorded at 100%, while the lowest was at 50% recommended dose of fertilizers. Fertility percentage remained unaffected due to different treatments. However, conventional tillage recorded numerically higher fertility percentage (2.59%) than zero tillage. Application of vermicompost @ 5 t/ha resulted in higher fertility (0.59%) than FYM @ 10 t/ha. Numerically maximum fertility percentage (86%) was recorded at 100% recommended dose of fertilizers. The highest 1,000-grain weight was recorded under conventional tillage, while the lowest was under zero tillage. The 1,000-grain weight remained unaffected due to organic manures. Application of 100% followed by 75% recommended dose of fertilizers resulted in higher test weight than 50% recommended dose of fertilizers (Table 1).

Yields

Conventional tillage followed by minimum tillage resulted in significantly higher grain, straw and biological yields than zero tillage. The results are in confirmation with those of Alam *et al.* (2014) and Feng *et al.* (2014). The highest grain yield was recorded with vermicompost @ 5 t/ha. Application of 100% recommended dose of fertilizers also recorded the highest grain yield. The highest straw yield was recorded with vermicompost @ 5 t/ha. The results confirm the findings of Nehra *et al.* (2001). Application of 100% RDF recorded the highest straw yield which was 11.82% higher than 50% recommended dose of fertilizers. Application of vermicompost @ 5 t/ha recorded significant increase in biological yield (5.08%) than FYM @ 10 t/ha. The results are in similarity to the findings of Nehra *et al.* (2001). The highest biological yield was recorded at 100% recommended dose of fertilizers. Our results confirm the the findings of Shahi *et al.* (2016). This might be owing higher values of yield attributes resulted in higher yields of wheat (Table 2).

The highest productivity was recorded under conventional tillage, while the lowest was under zero tillage. A higher productivity was recorded under vermicompost @ 5 t/ha (8.61%) than FYM @ 10 t/ha. Application of 100% recommended dose of fertilizers recorded significantly higher productivity (27.45%) than 50% recommended dose of fertilizers (Table 2). The highest productivity (16.65kg/ha/day) was observed at

Table 1. Effect of tillage, organic manures and fertilizer doses on yield attributes of wheat (pooled data of 2 years)

Treatment	Effective tillers/m^2	Ear length (cm)	Spikelets/ ear	Total number of grains/ear	Filled grains/ear	Fertility percentage (%)	1,000-grain weight (g)
Tillage							
ZT	288.3	9.6	18.3	49.4	41.1	83.2	37.2
MT	292.7	10.2	18.4	49.7	42.3	85.0	39.2
CT	300.2	10.9	19.0	51.3	43.8	85.3	40.8
SEm±	2.27	0.15	0.21	0.57	0.52	1.03	0.54
CD (P=0.05)	7.14	0.47	NS	NS	1.63	NS	1.71
Organic manures							
FYM (10 t/ha)	289.8	10.2	18.4	49.8	41.9	84.3	38.3
VC (5 t/ha)	297.7	10.3	18.7	50.6	42.9	84.8	39.8
SEm±	1.85	0.12	0.17	0.47	0.42	1.02	0.44
CD (P=0.05)	5.83	NS	NS	NS	NS	NS	NS
Fertilizer doses							
50% RDF	287.2	9.7	17.9	48.2	40.4	83.7	37.6
75% RDF	295.8	10.3	18.6	50.2	42.2	84.1	39.4
100% RDF	298.3	10.6	19.3	52.0	44.6	85.6	40.2
SEm±	2.81	0.18	0.28	0.76	0.78	1.05	0.63
CD (P=0.05)	8.21	0.53	0.82	2.22	2.27	NS	1.84

ZT, Zero tillage; MT, minimum tillage; CT, conventional tillage; RDF, recommended dose of fertilizers; FYM, farm yard manure; VC, vermicompost

100% recommended dose of fertilizers. Significantly higher harvest index was recorded under conventional tillage than zero tillage. The lowest harvest index was recorded under zero tillage. Significantly higher harvest index was observed with vermicompost @ 5 t/ha (3.67%) than FYM @ 10 t/ha. Application of 100% recommended dose of fertilizers recorded higher harvest index (9.13%) than 50% recommended dose of fertilizers but was at par with 75% recommended dose of fertilizers. The highest harvest index (31.43 %) was recorded at 100% recommended dose of fertilizers (Table 2).

Protein content

Tillage and organic manures did not affect seed protein content. However, maximum value of protein content (9.78%) was recorded under conventional tillage. Application of vermicompost @ 5 t/ha also resulted in maximum protein content. The results are in confirmation with the findings of Channabasanagowda *et al.* (2008). Application of 100% recommended dose of fertilizers resulted in significantly higher protein content (6.44%) followed by 75% recommended dose of fertilizers than 50% recommended dose of fertilizers (Table 2). This might be owing to higher application of fertilizers that resulted in more availability of nutrients.

Economics

Conventional tillage recorded significantly higher gross return (18.35%) than zero tillage, but at par with minimum tillage. The lowest gross return was recorded under zero tillage. Vermicompost @ 5 t/ha resulted in significantly higher gross return (6.82%) than FYM @ 10 t/ha. Application of 100% recommended dose of fertilizers recorded the highest gross return (65.05 × 10^3₹/ha) and it was 21.76% higher than 50% recommended dose of fertilizers. The highest net return (25.42 × 10^3₹/ha) was recorded under conventional tillage, while the lowest (18.45 × 10^3₹/ha) was under zero tillage. This might be owing to higher and lower yield under conventional and zero tillage respectively. No significant effect of organic manures was observed on net return. Application of 100% recommended dose of fertilizers recorded significantly higher net returns (47.75%) than 50% recommended dose of fertilizers. The highest net return (26.28 × 10^3₹/ha) was recorded at 100% recommended dose of fertilizers, while the lowest (17.79 × 10^3₹/ha) was at 50% recommended dose of fertilizers (Table 2).

Significantly higher benefit:cost ratio was recorded under conventional tillage (8.95%) than zero tillage. Benefit:cost recorded under conventional tillage was at par with the minimum tillage. Organic manures did not influence B:C ratio. Significantly higher B:C ratio

Table 2. Effect of tillage, organic manures and fertilizer doses on yield, productivity, harvest index, protein content and economics of wheat (pooled data of 2 years)

Treatment	Yield (t/ha)			Productivity (kg/ha/day)	Harvest index (%)	Protein content (%)	Gross returns (× 10^3₹/ha)	Net returns (× 10^3 ₹/ha)	Benefit: cost ratio	Profitability (₹/ha/day)
	Grain	Straw	Biological							
Tillage										
ZT	2.30	5.61	7.91	13.31	29.0	9.11	54.2	18.5	1.47	107
MT	2.64	5.99	8.63	15.23	30.4	9.55	60.5	23.3	1.62	135
CT	2.84	6.16	9.00	16.39	31.3	9.78	64.1	25.4	1.60	147
SEm±	0.08	0.07	0.13	0.46	0.54	0.29	1.4	1.4	0.02	8
CD (P=0.05)	0.25	0.22	0.42	1.46	1.70	NS	4.3	4.3	0.07	25
Organic manures										
FYM (10 t/ha)	2.48	5.82	8.30	14.36	29.7	9.28	57.6	21.9	1.58	127
VC (5 t/ha)	2.70	6.03	8.72	15.59	30.8	9.68	61.6	22.8	1.55	132
SEm±	0.07	0.06	0.11	0.38	0.44	0.23	1.1	1.1	0.02	6
CD (P=0.05)	0.21	0.18	0.35	1.19	1.39	NS	3.5	NS	NS	NS
Fertilizer doses										
50% RDF	2.26	5.58	7.84	13.06	28.8	9.16	53.4	17.8	1.49	103
75% RDF	2.63	5.95	8.58	15.22	30.5	9.53	60.3	23.1	1.56	134
100% RDF	2.88	6.24	9.12	16.65	31.4	9.75	65.1	26.3	1.65	152
SEm±	0.06	0.07	0.12	0.33	0.33	0.16	1.0	1.0	0.02	6
CD (P=0.05)	0.16	0.20	0.34	0.95	0.95	0.47	3.0	3.0	0.05	17

ZT, Zero tillage; MT, minimum tillage; CT, conventional tillage; RDF, recommended dose of fertilizers; FYM, farm yard manure; VC, vermicompost

(10.83%) was recorded at 100% than 50% recommended dose of fertilizers. The highest B:C (1.65) was recorded at 100% recommended dose of fertilizers while the lowest (1.49) was at 50% recommended dose of fertilizers (Table 2). Significantly higher profitability (37.71%) was recorded under conventional tillage followed by minimum tillage then zero tillage. The lowest profitability was recorded under zero tillage. Organic manures did not influence profitability. The highest profitability (151.85 ₹/ha/day) was recorded at 100% recommended dose of fertilizers while the lowest (102.82 ₹/ha/day) was at 50% recommended dose of fertilizers (Table 2).

The study inferred that minimum tillage, vermicompost @ 5 t/ha and 100% recommended dose of fertilizers are the best economical treatments for enhancing productivity, profitability and quality of wheat under mid-hill conditions of Himachal Pradesh.

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