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Productivity, profitability and quality of soybean (*Glycine max*) as influenced by tillage, organic manures and fertilizer doses

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ABSTRACT

A field experiment was conducted at Palampur, Himachal Pradesh during 2015 and 2016, to study the effect of tillage, organic manures and fertilizer doses on soybean [*Glycine max* (L.) Merr.]. The experiment was laid out in split plot design with six main-plots consisting of combination of three tillage (zero tillage, minimum tillage and conventional tillage) and two organic manures (vermicompost, 5 t/ha and FYM, 10 t/ha), and three sub-plots (50, 75 and 100% recommended dose of fertilizers). Tillage, organic manures and fertilizer doses significantly affected productivity, profitability and quality of soybean. Yield attributes (pods/plant, seeds/pod and test weight), yields, productivity, net returns, benefit:cost ratio and profitability were significantly better in conventional tillage, vermicompost and 100% recommended dose of fertilizers, respectively. Conventional tillage recorded significantly higher seed yield, productivity, profitability, oil and protein contents as compared to zero tillage. The treatment,100% recommended dose of fertilizers recorded significantly higher seed yield, productivity, profitability, oil and protein contents than 50 % recommended dose of fertilizers. Vermicompost recorded significantly higher seed yield and productivity as compared to zero tillage. Under performance of zero tillage might be due to manual seed drilling and poor soil drainage. Interaction effect of tillage, organic manures and fertilizer doses on soybean remained non-significant. Conventional tillage, vermicompost and 100 % recommended dose of fertilizers proved to be the best treatments for enhancing productivity, profitability and quality of soybean under mid-hill conditions of Himachal Pradesh.

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

Soybean [*Glycine max* (L.) Merr.] is the largest source of vegetable oil and protein in the world. India is the 5th largest producer of soybean in the world producing over 14008 thousand metric tonnes. Soya protein is considered as a complete protein as it supplies sufficient amount of different kinds of amino acids required for body building and repair of body tissues. Soybean is one of the most resilient crops for the rainfed rainy season performing well under aberrant weather conditions, minimum agricultural inputs, management practices and climatic adversities (Agarwal *et al.* 2013). Conservation tillage is considered better than conventional tillage as it improves various properties of soil. It also 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 also optimizes water storage capacity in the soil profile, enhances nutrient recycling in soil and lesser leaching of nutrients and increases number of micro-organisms.

Continuous application of fertilizers results in poor crop productivity and soil health. Organic manures improve physical, chemical and biological properties of soil by adding organic matter in the soil. Application of organic manures in combination with fertilizers enhances crop productivity and profitability. Organic manures are also cost effective and food grown through these is safe to eat. Considering the above said facts, the present investigation was conducted to study the effect of tillage, organic manures and fertilizer doses on soybean under mid-hill conditions of Himachal Pradesh.

MATERIALS AND METHODS

The field experiment was conducted for two consecutive rainy seasons in 2015 and 2016 at Agronomy Research Farm, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur. The area lies in Palam valley (32°11'N latitude and 76°32'E longitude) perched in the lap of majestic snow clad Dhauladhar range of Himalayas at an elevation of 1290 m amsl. The soil is silty-clay loam in texture and acidic in reaction (*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 rainy season of 2015, the weekly minimum and maximum temperature ranged from 10.2 to 19.8°C and 22.6 to 30.0°C, respectively.

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In second rainy season of 2016, the mean weekly minimum and maximum temperature ranged from 9.9 to 19.5°C and 23.5 to 29.1°C, respectively. Total rainfall received was 272.8 mm and 263.3 mm during first and second season of 2015 and 2016, respectively.

The experiment was laid out in split plot design with three replications. There were six main-plots consisting of six treatment combinations of three tillage practices (zero tillage, minimum tillage and conventional tillage) and two organic manures (vermicompost, 5 t/ha and FYM, 10 t/ha), and three sub-plots consisting of three fertilizer doses (50, 75 and 100% recommended dose of fertilizers). In the state, vermicompost is normally applied @half of recommended dose of farm yard manure which might be due to higher nutrient contents in vermicompost. Harit Soya was used as test variety sown at 45 cm × 10 cm spacing on 19th June and 18th June in 2015 and 2016, 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. Farmyard manure (FYM) and vermicompost were applied as per treatment at the time of sowing. Recommended dose of fertilizers (20:60:40) in the state was applied @50, 75 and 100 % at the time of sowing. The N, P and K nutrients were applied through urea, SSP and muriate of potash, respectively. For control of weeds, pendimethalin @1.5 kg/ha plus 750 l of water was sprayed just after sowing of the soybean crop. In addition, one hand weeding was also done at 35 days after sowing. Paraquat @0.6 l/ha plus 750 l of water was also sprayed a week before sowing of the crop in zero tillage plots. Other package of practices recommended for the region was also followed. Data were recorded on yield attributes, yields, economics and quality of soybean and subjected to analysis of variance with mean comparison of 5% level of significance.

RESULTS AND DISCUSSION

Effect of tillage, organic manures and fertilizer doses on yield attributes: Primary branches per plant were not influenced by tillage and organic manures during both the years. However, maximum branches per plant were recorded under conventional tillage while minimum was under zero tillage. Application of vermicompost @5 t/ha recorded numerically higher branches per plant as compared to farmyard manure (FYM) @ 10 t/ha. The highest branches per plant was recorded at 100% recommended dose of fertilizers while the lowest branches per plant was at 50% recommended dose of fertilizers during both the years (Table 1). Application of fertilizers enhances nutrient availability to the crop plants resulting in better yield attributes.

The highest number of pods per plant was recorded in conventional tillage while the lowest was under zero tillage. The results are in confirmation with Monsefi *et al.* (2014). Application of vermicompost @5 t/ha recorded significantly higher number of pods per plant during 2015. Devi *et al.* (2013), Moghadam *et al*. (2014) and Pati and Udmale (2016) also recorded similar findings. The highest number of pods per plant was recorded at 100% recommended dose of fertilizers (Table 1). Similar trends were also noted by Shinde *et al.* (2015).

Seeds per pod were significantly affected by tillage during 2016. Significantly higher number of seeds per pod was recorded under conventional tillage followed by minimum tillage than zero tillage during 2016 (Table 1). Similar findings were also reported by Monsefi *et al.* (2014). Application of vermicompost @5 t/ha resulted in significantly higher number of seeds per pod. Devi *et al.*

Table 1 Effect of tillage, organic manures and fertilizer doses on yield attributes of soybean

Treatment	Primary branches		Pods/plant		Seeds/pod		Test weight (g)	
	2015	2016	2015	2016	2015	2016	2015	2016
Tillage								
ZT	3.50	3.56	58.00	59.44	2.44	2.83	131.93	138.75
MT	3.50	3.56	59.67	59.83	2.50	3.06	132.33	142.67
CT	3.56	3.67	61.67	61.00	2.56	3.28	133.90	144.77
LSD (P=0.05)	NS	NS	0.68	1.14	NS	0.28	1.52	2.06
Organic manures								
FYM (10 t/ha)	3.41	3.44	59.48	59.63	2.30	2.93	132.35	140.96
VC (5 t/ha)	3.63	3.74	60.07	60.56	2.70	3.19	133.10	143.17
LSD (P=0.05)	NS	NS	0.56	NS	0.38	0.23	NS	1.68
Fertilizer doses								
50 % RDF	3.17	3.28	58.17	58.50	2.28	2.78	132.08	140.37
75 % RDF	3.50	3.67	59.39	59.83	2.56	3.00	132.54	142.26
100 % RDF	3.89	3.83	61.78	61.94	2.67	3.39	133.55	143.55
LSD (P=0.05)	0.33	0.30	0.69	0.76	0.26	0.36	0.79	1.58

ZT, Zero tillage; MT, Minimum tillage; CT, Conventional tillage; RDF, Recommended dose of fertilizers.

(2013), Pati and Udmale (2016) reported similar findings. The treatment comprising 100% recommended dose of fertilizers recorded significantly higher number of seeds per pod followed by 75% recommended dose of fertilizers than 50% recommended dose of fertilizers during 2015. The highest number of seeds per pod was noted at 100 % recommended dose of fertilizers during 2016. Hosmath *et al.* (2012) and Shinde *et al.* (2015) also reported similar results.

The highest test weight was recorded in conventional tillage during 2015. During second year, significantly higher test weight was recorded in conventional tillage followed by minimum tillage than zero tillage. As far as effect of organic manures was concerned, no significant difference was observed in test weight during 2015 while in second year significantly higher 1000-seed weight was observed with application of vermicompost @5 t/ha than FYM @10 t/ha. Application of 100% recommended dose of fertilizers recorded the highest 1000-seed weight in first year. During second year, significantly higher 1000-seed weight was recorded at 100% recommended dose of fertilizers followed by 75% recommended dose of fertilizers than 50% recommended dose of fertilizers (Table 1). Similar results have been documented by Devi *et al.* (2013), Pati and Udmale (2016). Interaction effect of tillage, organic manures and fertilizer doses on yield attributes remained non-significant.

Effect of tillage, organic manures and fertilizer doses on yields: Seed yield was significantly affected by tillage, organic manures and fertilizer doses during both the years. Conventional tillage resulted in the highest seed yield (1980 kg/ha in 2015 and 2029 kg/ha in 2016). There was 18.51 and 12.78% increase in seed yield under conventional tillage than zero tillage during 2015 and 2016, respectively (Table 2). This might be due to higher values of yield attributes under conventional tillage. Minimum tillage resulted in higher seed yield than zero tillage. The lowest seed yield was observed under zero tillage. The results are in confirmation with Monsefi *et al.* (2014). Significantly higher seed yield was recorded under application of vermicompost @5 t/ha over FYM. This might be due to higher nutrient contents in vermicompost resulting in higher nutrient availability to crop plants. Similar results were observed by Devi *et al.* (2013), Moghadam *et al.* (2014), Pati and Udmale (2016). The treatment comprising 100% recommended dose of fertilizer recorded the highest seed yield while the lowest seed yield was observed at 50% recommended dose of fertilizer. This might be due to more availability of nutrients to the crop plants in this treatment. Bandhopadhyay *et al*. (2010) and Shinde *et al.* (2015) also reported similar findings.

Significantly higher stover yield was recorded under conventional tillage followed by minimum tillage during 2015. The minimum stover yield was recorded under zero tillage. As far as organic manures were concerned, no significant effect was observed during first year. In 2016, application of vermicompost @5 t/ha resulted in significantly higher stover yield than FYM @10 t/ha. The results are similar to findings documented by Devi *et al.* (2013) and Pati and Udmale (2016). The treatment comprising of 100% recommended dose of fertilizers recorded significantly higher stover yield followed by 75% recommended dose of fertilizer than 50% recommended dose of fertilizer (Table 2). Similar results were found by Shinde *et al.* (2015).

The highest productivity was recorded under conventional tillage while the lowest was under zero tillage. This was due to higher seed yield under conventional tillage than zero tillage. Among different organic manures,

Table 2 Effect of tillage practices, organic manures and fertilizer doses on yields, productivity and harvest index of soybean

Treatment	Seed yield (t/ha)		Stover yield (t/ha)		Biological yield (t/ha)		Productivity (kg/ha/day)		Harvest index (%)	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Tillage										
ZT	1.7	1.8	2.9	2.9	4.6	4.7	12.09	12.76	36.43	38.10
MT	1.8	1.9	3.0	3.0	4.9	4.9	13.04	13.43	36.85	38.63
CT	2,0	2.0	3.1	3.1	5.1	5.1	14.35	14.39	38.63	39.87
LSD (P=0.05)	0.08	0.11	0.17	NS	142	0.23	0.59	0.78	NS	NS
Organic manures										
FYM (10 t/ha)	1.8	1.8	3.0	2.9	4.7	4.7	12.79	13.10	37.18	38.68
VC (5 t/ha)	1.9	2.0	3.1	3.1	5.0	5.1	13.52	13.95	37.43	39.06
LSD (P=0.05)	0.07	0.09	NS	0.17	0.01	0.19	0.48	0.64	NS	NS
Fertilizer doses										
50 % RDF	1.7	1.8	2.9	2.9	4.6	4.7	12.10	12.69	36.18	38.07
75 % RDF	1.8	1.9	3.1	3.0	4.9	4.9	13.21	13.74	37.32	39.15
100 % RDF	2.0	2.0	3.1	3.1	5.1	5.1	14.16	14.14	38.42	39.38
LSD (P=0.05)	0.07	0.06	0.11	0.15	0.14	0.14	0.54	0.49	1.28	NS

ZT, Zero tillage; MT, Minimum tillage; CT, Conventional tillage; RDF, Recommended dose of fertilizers.

significantly higher productivity was noted with the application of vermicompost @5 t/ha as compared to FYM @10 t/ha. Application of 100% recommended dose of fertilizers recorded the highest value of productivity in 2015 while in 2016, significantly higher productivity was recorded at 100% followed by 75% recommended dose of fertilizers than 50 % recommended dose of fertilizers (Table 2).

Harvest index was not significantly affected by tillage and organic manures during both the years. However, numerically higher harvest index was recorded under conventional tillage and application of vermicompost @5 t/ha during both the years, respectively. In 2015, harvest index was significantly higher at 100% recommended dose of fertilizers followed by 75% recommended dose of fertilizers than 50% recommended dose of fertilizers. During 2016, it remained unaffected under different fertilizer doses (Table 2). Interaction effect of tillage, organic manures and fertilizer doses on yields remained non-significant.

Effect of tillage, organic manures and fertilizer doses on economics: Gross returns were significantly affected by tillage during both the years. The highest gross returns were recorded under conventional tillage. Significantly higher gross returns were observed under conventional tillage than zero tillage. This was due to higher seed and stover yield recorded under same treatment. Application of vermicompost @5 t/ha recorded significantly higher gross returns than FYM @10 t/ha. This was due to higher seed and stover yield recorded in the same treatment as compared to FYM @10 t/ha. The data given in Table 3 revealed that the highest gross returns was at 100% recommended dose of fertilizers. An increase of 15.21% and 10.70% at 100% recommended dose of fertilizer over 50% recommended dose of fertilizer was observed during 2015 and 2016, respectively (Table 3). The lowest gross returns were recorded at 50 % recommended dose of fertilizers.

Net returns were significantly affected by different treatments during 2015. The highest net returns were recorded under conventional tillage in 2015. During 2016, net returns were not affected by tillage, but numerically higher net returns were recorded under conventional tillage. The lowest net returns was noted under zero tillage. Organic manures did not affect net returns during both the years. However, numerically higher value of net returns was observed under vermicompost @5 t/ha than FYM @10 t/ha. The highest net returns was recorded at 100% recommended dose of fertilizers in 2015. In 2016, application of 100% followed by 75% recommended dose of fertilizers recorded significantly higher net returns than 50% recommended dose of fertilizers. The lowest net returns were observed at 50% recommended dose of fertilizers during both the years (Table 3).

Conventional tillage followed by minimum tillage recorded significantly higher benefit cost ratio (B:C) than zero tillage. This was due to higher seed and stover yield leading to more returns under conventional tillage. As far as organic manures were concerned, B:C was found to be non-significant during both the years. However, numerically higher B:C was recorded under vermicompost @5 t/ha than FYM @ 10 t/ha. Significantly higher B:C was recorded at 100% followed by 75% recommended dose of fertilizers than 50% recommended dose of fertilizers (Table 3).

Conventional tillage recorded the highest profitability in 2015 while in 2016, no significant difference was observed under different tillage practices. However, numerically higher profitability was recorded under conventional tillage.

Table 3 Effect of tillage practices, organic manures and fertilizer doses on economics and quality of soybean

Treatment	Gross returns (₹×10^3/ha)		Net returns (₹x10^3/ha)		B:C ratio		Profitability (₹/ha/day)		Protein content (%)		Oil content (%)	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Tillage												
ZT	60.2	64.2	22.6	26.6	1.6	1.7	164	189	36.12	37.24	18.13	18.98
MT	64.8	67.4	25.6	28.2	1.7	1.7	186	200	36.98	38.16	18.98	19.65
CT	70.4	71.6	29.5	30.6	1.7	1.7	214	217	38.34	39.54	19.82	20.77
LSD (P=0.05)	2.1	3.4	2.1	NS	0.1	NS	15.4	NS	1.63	1.51	0.82	0.76
Organic manures												
FYM (10 t/ha)	63.4	65.6	25.8	27.9	1.7	1.7	187	198	36.50	37.77	18.92	19.56
VC (5 t/ha)	66.9	69.9	26.0	29.0	1.6	1.7	187	206	37.79	38.85	19.03	20.04
LSD (P=0.05)	1.7	2.7	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Fertilizer doses												
50 % RDF	60.4	63.9	22.6	26.1	1.6	1.7	164	185	36.50	37.67	18.44	19.33
75 % RDF	65.4	68.6	26.3	29.5	1.7	1.7	190	209	37.17	38.27	19.06	19.85
100 % RDF	69.6	70.7	28.8	29.9	1.7	1.8	209	212	37.77	38.99	19.44	20.21
LSD (P=0.05)	2.3	1.9	2.3	1.9	0.1	0.05	17	14	0.83	1.00	0.64	0.53

ZT, Zero tillage; MT, Minimum tillage; CT, Conventional tillage; RDF, Recommended dose of fertilizers.

No significant difference due to different organic manures was observed on profitability in both the years. However, numerically higher profitability was observed under vermicompost @5 t/ha than FYM @10 t/ha. Application of 100% recommended dose of fertilizers recorded the highest profitability in 2015. In 2016, application of 100% followed by 75% recommended dose of fertilizers recorded significantly higher profitability than 50% recommended dose of fertilizers (Table 3). Interaction effect of tillage, organic manures and fertilizer doses on economics remained non-significant.

Effect of tillage, organic manures and fertilizer doses on quality parameters: The data given in Table 3 revealed that protein content under conventional tillage followed by minimum tillage was significantly higher than zero tillage. Zero tillage recorded the lowest protein content. No significant effect of organic manures on protein content was observed during both the years. Application of 100% followed by 75% recommended dose of fertilizers recorded significantly higher protein content than 50% recommended dose of fertilizers. Application of 50% recommended dose of fertilizers recorded the lowest protein content (Table 3). The highest value of oil content was recorded in conventional tillage while the lowest was in zero tillage during both the years. Organic manures did not affect oil content. Fertilizers @100% followed by 75% recommended dose of fertilizers recorded significantly higher oil content as compared to 50% recommended dose of fertilizers. The lowest oil content was recorded at 50% recommended dose of fertilizers (Table 3). Interaction effect of tillage, organic manures and fertilizer doses on protein and oil contents remained non-significant.

From the above said findings, it can be concluded that conventional tillage, vermicompost @5 t/ha and 100% recommended dose of fertilizers are the best treatments for enhancing productivity, profitability and quality of soybean under mid-hill conditions of Himachal Pradesh.

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