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Quality traits under different farming practices in legume-based cropping systems

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Abstract

Field experiments were conducted at Organic Farm Holta of Department of Organic Agriculture and Natural Farming, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur during kharif and rabi seasons of 2018-19 and 2019-20 on silty clay loam soil to study the performance of different quality traits under different farming practices in legume-based cropping systems. The experiment was laid out under Split Plot Design with three replications comprising of three sequences in legume – vegetable based cropping system i.e., "soybean – onion", "okra – peas" and "mash – garlic" under different farming practices i.e., Organic farming, Natural farming, Inorganic and Integrated farming practices.Comparing different farming practices, highest protein content (39.1%) was observed in crops under organic farming practices followed by zero budget natural farming practices (38.3%). Significantly higher protein yield of these crops was also recorded under organic farming practices (449 kg/ha) followed by integrated farming practices (405 kg/ha).Carbohydrate yield (1127 kg/ha) and fat yield (120 kg/ha) of crops were significantly highest in integrated farming practices and inorganic farming practices respectively. "Soybean-onion" cropping system produced significantly highest protein yield (644 kg/ha) and fat yield (300.7 kg/ha) as compared to other cropping systems. However, higher protein content and low carbohydrate and fat were recorded in this system when grown under organic farming practices and was found to be the best amongst all cropping systems and farming practices combinations.

Key words: Cropping System, Farming Practices, Quality, Protein.

With the growing population, food security has always been every man's issue, but now the time has come when there is a need to be also concerned about the nutritional security i.e., quality of the produce consumed and its effects on human health. Vegetables, fruits and cereals are the main sources of nutritious dietary components. These not only aid in the maintenance of human health but also in developing resistance to diseases and infections. Vegetables are mainly rich in antioxidants, minerals and vitamins. Daily consumption of the recommended quantity of vegetables is beneficial to human health. Non-communicable diseases like cancer and cardio-vascular diseases are linked to decreased intake of high-quality vegetables. In today's world of polluted environment, human beings are exposed to attack of a number of bacteria and virus infections. The only one way to tackle these situations is to boost human immunity system which can be easily done by adoption of high-quality vegetables and fruits in daily lifestyle (Slavin and Lloyd 2012). Vegetables provide mineral nutrients that are vital for good health and maintenance of our body. Potassium, dietary fibre, folic acid, vitamin A and vitamin C are the important mineral nutrients and are available in plenty in most veggies. They also have minimal fat and calorie content. Potassium in the diet aids in the maintenance of normal blood pressure. In this regard, the World

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Health Organization (WHO) recommends eating more than 400 g of fruits and vegetables each day to preserve good health and lower the risk of non-communicable illnesses.

The quality of vegetables is largely determined by farming practices and post-harvest handling procedures. The farming practices (Hogland *et al*. 2018), and all management methods used have a significant impact on vegetable quality (Roupharl *et al*. 1999). Nutritional quality of vegetables is strongly influenced by environmental conditions, especially light intensity and temperature, soil type and other cultural practices but major role is played by different farming practices which have been shown to affect the nutritional composition and quality attributes of the harvested plant (Goldman *et al*. 2018).

Organic farming is a production system that promotes soil, ecosystem and human health. Rather than using harmful inputs, it relies on biological processes, biodiversity and cycles that are tailored to local conditions. Organic farming combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved. Organic vegetable production methods that are well-managed can provide food security and a nutritious diet for humans while also being less destructive to the environment and more resource efficient (Smukler *et al*. 2008). Keeping this in mind, the present experiment was undertaken to assess the quality of the produce grown under different farming practices.

Materials and Methods

A field experiment was conducted during kharif and rabi seasons of 2018–19 and 2019–20 at Organic Farm Holta of Department of Organic Agriculture and Natural Farming, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur. The experimental site is geographically located at 32°6' N latitude and 76°3' E longitude at an elevation of about 1224 meters above mean sea level. The soil of the experimental field was silty clay loam in texture, acidic in reaction (pH 5.12), low in available nitrogen (229 kg/ha), medium in available phosphorus (14.5 kg/ha) and medium in available potassium (236 kg/ha).

The experiment was laid out under Split Plot Design with three replications comprising of three sequences in legume – vegetable based cropping system i.e., "soybean – onion", "okra – peas" and "mash –garlic". The varieties of crops i.e., soybean 'Harit Soya', okra 'Punjab -8', mash 'UG218', onion 'Patna red', peas 'Punjab 89' and garlic 'GHC-1'were raised under different farming practices i.e., organic farming, natural farming, inorganic and integrated farming.

In organic farming practices, seed treatment with *Jeevamrit* @10%, vermicompost @ 5 t/ha (soybean, mash), 10 t/ha (okra, onion, peas, garlic) + 6 sprays of vermiwash as per recommendations of the department were followed and in natural farming practices, soil treatment with *jeevamrit* @10 %, *ghanjeevamrit* 250 kg/ha and sieved FYM 250 kg/ha + spray of jeevamrit after 21 days interval were followed. Under inorganic farming practices, recommended dose of NPK was followed whereas in integrated farming practices, half dose of inorganic NPK and half the dose of organic practices were followed. There was no severe attack of any insect-pest and disease. The samples were analyzed and data was recorded on quality parameters/nutritional composition of different crops i.e., Crude protein (%), Carbohydrate (%) and Fat (%). Crude protein in each crop sample was calculated by multiplying the total N by 6.25 except in soybean where, it was calculated by multiplying by 5.71 (AOAC 2000 and Gopalan *et al*. 2007). Crude fat was measured by method advocated by AOAC (2000) and Carbohydrate (%) was measured by Hedge and Hofreiter (1962). Protein, Carbohydrate and Fat yield (kg/ha) were calculated by multiplying content with seed yield and dividing by 100. Data were subjected to analysis of variance with mean comparison of 5% level of significance and was statistically analyzed as per the procedure outlined by Gomez and Gomez (1984).

Results and Discussion

Crude protein content (%) and yield (kg/ha)

During both the years, the highest protein content (39.1%) was found in soybean under organic farming practices, whereas the lowest protein content (33.5%) was found under inorganic farming practices (Table

1). The same pattern was found in all crops e.g. in okra, protein content varied from 11.2-13.4%, under mash from 15.1 to 18.4 %, in onion 0.4-0.8%, in peas 17.6-21.7 % and in garlic, it varied from 6.7% under inorganic to 6.9% under organic farming practices. This may be due to application of chemical nutrients which reduced the N fixation process in the rhizosphere zone (Hyten *et al*. 2004) and subsequently inhibited the protein synthesis. Also, transformation and translocation of protein in the plant system could not occur adequately and therefore, further mobilization of protein was restricted in the ultimate sink i.e., the seed which resulted in deposition of lower protein content. Kumar *et al*. (2020) also concluded in one of the studies that highest protein content was found in crops grown under organic farming practices as compared to other farming practices.

Protein yield was significantly highest (449 kg/ha) under organic farming practices and lowest protein yield (360 kg/ha) was found in inorganic farming practices during both the years (Table 2). "Soybean-onion" cropping system produced significantly highest protein yield (644 kg/ha). This may be due to the high protein content of legumes that can be attributed to their association with the activity of the nitrogen-fixing bacteria in their roots which convert the unusable nitrogen gas into ammonium which is incorporated by the plant into protein synthesis (Blazos and Baleski 2016). Lowest protein yield (176 kg/ha) was found in "mash-garlic" cropping system in both the years. Deshmukh *et al*. (2005) also reported that application of vermicompost to soybean increased the protein yield over chemical fertilizers.

Carbohydrate content (%) and yield (kg/ha)

In both the years, soybean grown under inorganic farming practices had the highest carbohydrate content (37.8 %), whereas organic farming practices resulted in the lowest (34.2%) carbohydrate content (Table 1). The same pattern was observed in all the crops e.g. in okra, carbohydrate content ranged from 62.2 to 63.6%, in mash from 65.3 to 68.6%, in onion the carbohydrate content ranged from 68.0 to 71.2 %, in peas it ranged from 64.1 to 66.5% whereas in garlic the range was from 34.9 to 38.9 % under organic and inorganic farming practices respectively. It was found that the successive addition of fertilizers progressively increased the carbohydrate content in vegetable crops. Similar results were found by Bachhav and Sabale (1996) and Esmailian *et al*. (2011) in soybean where highest carbohydrate content (67.9 %) was found in inorganic farming practices in soybean.

Carbohydrate yield was significantly highest (1127 kg/ha) under integrated farming practices and was statically at par with inorganic (1102 kg/ha) and organic farming practices (1091 kg/ha). Similar results were found by Javed and Panwar (2013) and it was concluded that maximum carbohydrate yield was obtained withcombined application of chemical fertilizer with vermicompost over alone application of chemical fertilizer. Lowest carbohydrate yield (947 kg/ha) was found in crops grown under zero budget natural farming practices (Table 3). Among cropping system "okra-peas" cropping system produced significantly highest (1407 kg/ha) carbohydrate yield. Lowest carbohydrate yield (746 kg/ha) was found in "mash-garlic" cropping system in both the years. Lowest carbohydrate yield was due to less seed yield produced by mash crop.

Fat content (%) and yield (kg/ha)

During both the years, the highest crude fat content (21.3%) was found in soybean under inorganic farming practices, whereas the lowest fat content (18.2 %) was found under organic farming practices (Table 1). The same pattern was found in all the crops. In okra, fat content varied from 0.2-0.3%, in mash from 1.9 to 2.8 %, in onion 0.1 -0.3%, in peas 0.1 -0.2 % and in garlic; it varied from 0.2 % under organic to 0.5 % under inorganic farming practices. Similar results were reported by Kumar *et al*. (2017) while evaluating the performance of black gram under organic and inorganic farming practices. Highest crude fat % was found in inorganically grown black gram as compared to organically grown crop.

Inorganic farming practices produced significantly highest fat yield (120.0 kg/ha) which was closely followed by integrated farming practices (113.5 kg/ha). Lowest fat yield (97.1 kg/ha) was found in crops grown with zero budget natural farming

Table 1. Quality parameters of different crops grown under different farming practices

Treatment	Organic		ZBNF		Inorganic		Integrated	
	2018	2019	2018	2019	2018	2019	2018	2019
Crops				**Soybean**				
Protein (%)	38.4(4.9)	39.1(4.8)	37.7(4.2)	38.3(4.0)	33.5	34.3	34.3(0.8)	35.3(1.0)
Carbohydrate (%)	34.2(-3.2)	34.8(-3.0)	35.2(-2.2)	35.5(-2.4)	37.4	37.8	37.0(-0.4)	37.1(-0.7)
Fat (%)	18.2(-2.0)	18.3(-3.0)	18.9(-1.3)	19.0(-2.3)	20.2	21.3	19.6(-0.6)	19.9(-1.5)
				Okra				
Protein (%)	12.9(1.7)	13.4(1.5)	12.2(0.9)	13.0(1.1)	11.2	11.9	11.8(0.6)	12.6(0.7)
Carbohydrate (%)	62.2(-1.2)	62.3(-1.2)	62.9(-0.4)	62.7(-0.8)	63.4	63.6	63.1(-0.3)	63.4(-0.2)
Fat (%)	0.2(-0.1)	0.2(-0.1)	0.2(-0.1)	0.2(-0.1)	0.3	0.3	0.2(-0.1)	0.2(-0.1)
				Mash				
Protein (%)	17.8(2.7)	18.4(2.5)	17.4(2.3)	17.8(1.8)	15.1	15.9	16.6(1.4)	17.0(1.1)
Carbohydrate (%)	65.3(-2.9)	65.4(-3.2)	65.6(-2.7)	66.0(-2.6)	68.3	68.6	67.2(-1.1)	67.4(-1.2)
Fat (%)	1.9(-0.8)	2.1(-0.7)	2.2(-0.5)	2.3(-0.6)	2.7	2.8	2.3(-0.4)	2.4(-0.4)
				Onion				
Protein (%)	0.7(0.3)	0.8(0.3)	0.6(0.1)	0.6(0.1)	0.4	0.5	0.5(0.1)	0.6(0.1)
Carbohydrate (%)	68.0(-3.0)	68.4(-2.8)	68.3(-2.7)	68.5(-2.7)	71.0	71.2	70.6(-0.4)	70.9(-0.3)
Fat (%)	0.1(-0.2)	0.1(-0.1)	0.2(-0.1)	0.2(-0.1)	0.3	0.3	0.2(-0.1)	0.2(-0.1)
				Peas				
Protein (%)	20.5(2.9)	21.7(3.0)	19.6(2.1)	20.1(1.4)	17.6	18.7	18.5(1.0)	19.7(1.0)
Carbohydrate (%)	64.1(-2.1)	64.3(-2.1)	64.6(-1.6)	64.9(-1.6)	66.2	66.5	65.6(-0.6)	65.9(-0.5)
Fat (%)	0.1(-0.1)	0.1(-0.1)	0.2(-0.1)	0.2(-0.1)	0.2	0.2	0.2(-0.1)	0.2(-0.1)
				Garlic				
Protein (%)	6.8(0.1)	6.9(0.1)	6.8(0.1)	6.8(0.1)	6.7	6.8	6.8(0.1)	6.8(0.1)
Carbohydrate (%)	34.9(-2.4)	35.5(-3.5)	33.7(-3.6)	34.7(-4.3)	37.2	38.9	36.2(-1.0)	37.3(-1.6)
Fat (%)	0.2(-0.3)	0.2(-0.3)	0.4(-0.1)	0.4(-0.1)	0.5	0.5	0.4(-0.1)	0.4(-0.1)

*Figures in parentheses show per cent difference in comparison to inorganic farming practice

Table 2. Effect of different farming practices and cropping systems on protein yield (kg/ha)

Treatment	*Kharif*		*Rabi*		Cropping system	
	2018	2019	2018-19	2019-20	2018-2019	2019-2020
Farming practices (M)						
Organic (M_1)	290	297	139	152	429	449
Zero budget natural farming (M_2)	245	263	123	132	368	394
Inorganic (M_3)	244	250	116	125	360	375
Integrated (M_4)	259	267	126	138	385	405
LSD (P = 0.05)	28	24	10	6	23	12
Cropping systems (S)						
Soybean-Onion (S_1)	551	560	71	84	622	644
Okra-Peas (S_2)	84	91	274	292	358	384
Mash-Garlic (S_3)	143	156	33	34	176	191
LSD (P = 0.05)	18	14	6	7	15	13

Table 3. Effect of different farming practices and cropping systems on carbohydrate yield (kg/ha)

Treatment	Kharif		Rabi		Cropping system	
	2018	2019	2018-19	2019-20	2018-2019	2019-2020
Farming practices (M)						
Organic (M_1)	535	539	538	552	1073	1091
Zero budget natural farming (M_2)	449	501	498	511	947	1011
Inorganic (M_3)	548	550	538	552	1086	1102
Integrated (M_4)	552	556	550	571	1102	1127
LSD (P = 0.05)	46	42	49	41	37	54
Cropping systems (S)						
Soybean-Onion (S_1)	551	553	482	501	1034	1055
Okra-Peas (S_2)	440	453	937	954	1377	1407
Mash-Garlic (S_3)	571	604	174	184	746	787
LSD (P = 0.05)	23	25	32	27	28	42

Table 4. Effect of different farming practices and cropping systems on fat yield (kg/ha)

Treatment	Kharif		Rabi		Cropping system	
	2018	2019	2018-19	2019-20	2018-2019	2019-2020
Farming practices (M)						
Organic (M_1)	103.0	103.9	1.2	1.5	104.2	105.3
Zero budget natural farming (M_2)	95.3	97.3	1.7	1.9	97.1	99.2
Inorganic (M_3)	112.8	117.5	2.4	2.5	115.2	120.0
Integrated (M_4)	110.4	111.3	2.0	2.2	112.4	113.5
LSD (P = 0.05)	11.6	11.3	0.1	0.1	7.8	6.3
Cropping systems (S)						
Soybean-Onion (S_1)	295.0	299.2	1.4	1.6	296.4	300.7
Okra-Peas (S_2)	1.5	1.6	2.3	2.6	3.8	4.2
Mash-Garlic (S_3)	19.7	21.7	1.8	2.0	21.4	23.7
LSD (P = 0.05)	7.0	8.1	0.1	0.1	6.7	4.5

practices. "Soybean – onion" cropping system produced significantly highest fat yield (300.7 kg/ha) whereas the lowest fat yield was recorded in "okra-peas" cropping system in both the years. Adewole and Ilesanmi (2011) also concluded in their study that use of chemical fertilizers increased the carbohydrate and fat yield as well as the ash content in the produce (Table 4).

Conclusions

Organically grown crops (legumes and vegetables) are rich in protein yield having less energy in terms of carbohydrates and fats. On the other hand, foods are rich in carbohydrates and fats when grown under integrated and inorganic farming practices. Food crops (Okra, peas) grown under zero budget natural farming practices were nutritiously poor (in terms of the major food nutrients - proteins, carbohydrates and fats). Amongst the three cropping systems, soybean-onion cropping system was found to be nutritiously best in terms of protein and fats and among the farming practices organic farming practices were found to be best in terms of quality of legumes and vegetables crops.

Conflict of interest: The authors declare that there is no conflict of interest in this research paper.

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