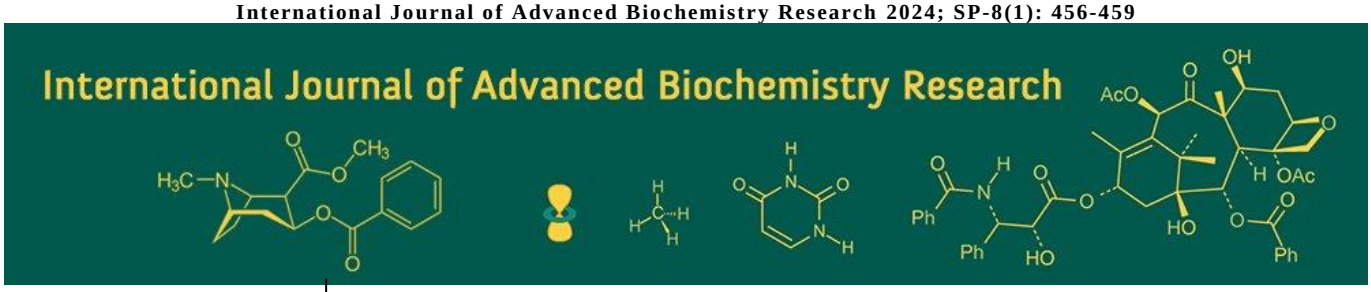

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Effect of different cropping systems and organic integrated nutrient management on protein yield and availability of quality protein

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Abstract
The experiment entitled, "Impact of organic nutrient modules on productivity of cropping systems, pest dynamics and soil quality," was carried out in the plot No. 76 at Agronomy Research Farm, Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during *kharif* and *rabi* season of 2018-19 and 2019 - 20. The soil of the experimental plot was clayey in texture having swell shrink property. The experiment was laid out in strip plot design (SrPD) with six main plot factors and three sub plot factors comprising of cropping rotations/systems (6) and organic integrated nutrient management (3) and replicated thrice. Accordingly, in all eighteen treatment combinations were studied to find out the effect of organic nutrient module on cropping system. The findings revealed that the protein content and protein yield was found highest in pigeonpea + soybean (1:4) in first year and pigeonpea + soybean (1:3) in second year. In both years total protein yield and available quality protein was found highest in pigeonpea + soybean (1:4) and pigeonpea + soybean (1:3) cropping sequence followed by blackgram – chickpea in first year and cotton + blackgram (2:1) in second year over rest of the cropping sequence. Protein content (%) and protein yield (kg ha^{-1}) was found maximum with 75% FYM + Vermicompost (top dressing) + 25% Neem cake, followed by 100% FYM + Vermicompost. Total protein yield (kg ha^{-1}) and available quality protein was found maximum in 75% FYM + Vermicompost (top dressing) + 25% Neem cake (471.1 kg ha^{-1}).

Keywords: Organic, cropping system, protein, protein yield, crop rotation

Introduction
Organic agriculture is a production system that sustains the health of soil, surrounding ecosystem and people. It relies on ecological processes, biodiversity and cycles adapted to local condition rather than the use of inputs with adverse effect. Organic agriculture combines tradition, innovation and science to benefit the shared environment with fair relationship and good quality of life for all involved. Unlike chemical farming, organic farming aims to "feed the soil" rather than "feed the plant". It means giving back to the nature what has been taken from it. Since organic farming aims to maintain soil health and to obtain highest yield in a sustainable and ecofriendly manner on the long term basis.

After green revolution natural fertility of the soil has been degraded due to intensive cultivation, use of high doses of chemical fertilizers and insufficient use of organics i.e. farm yard manure, compost, crop residue, green manure, biofertilizers etc. At present we face many challenges to achieve sustainable food security and quality of food materials. In organic farming the management of crop residue plays an important role in improving the soil fertility and it depends upon the content of organic matter in soil. In organic farming it is widely accepted that high soil organic matter means high potential productivity and health of soil. In organic farming the soil biological condition increases day by day due to recycling of agricultural waste materials and utilization of all natural resources. Increasing awareness about conservation of environment as well as health hazards associated with agrochemicals and consumer preference to safe and hazards free food are the major factors that lead the growing interest in organic agriculture in the world. Organic agriculture is one of the broad spectrums of production methods, being considered in support of the environment soil and human health.

Crop rotation is one of the important practice known to reduce infestation of insect pests and diseases and weeds. This system not only provides organic matter to the soil but also proved to be profitable cropping system. But continuous growing of any crop or cropping system may leads to increase the intensity of pest, disease and weeds. To break their life cycle crop rotation is must. Crop rotation affect the insect population by altering the microclimate or by encouraging the natural enemies of the insect pest in the system. Inclusion of legumes in the cropping system is very effective not only from the point of nitrogen fixation but judicious utilization of soil nitrogen also. Legumes are dual purpose crops as they not only produce protein rich grains but also fix considerable amounts of nitrogen in the soil. Moreover, after harvest of crops their residue is incorporated in to the soil *in-situ* these help greatly in improving physico – chemical properties of the soil.

Methodology

The experiment entitled, "Impact of organic nutrient modules on productivity of cropping systems, pest dynamics and soil quality," was carried out in the plot No. 76 at Agronomy Research Farm, Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during *kharif* and *rabi* season of 2018-19 and 2019 - 20. The soil of the experimental plot was clayey in texture having swell shrink property. It was slightly alkaline in reaction (pH 8.1), low in organic carbon (0.44%), available nitrogen (193.68 kg ha^{-1}), available phosphorus (14.61 kg ha^{-1}) and high in available potassium (323.99 kg ha^{-1}). The experiment was laid out in strip plot design (SrPD) with six main plot factors and three sub plot factors comprising of cropping rotations/systems (6) and organic integrated nutrient management (3) and replicated thrice. Accordingly, in all eighteen treatment combinations were studied to find out the effect of organic nutrient module on cropping system. The crop and variety were PKV-Tara (Pigeonpea), AMS-1001 (Soybean), Co 1 (Foxtail millet), AKA-7 (Cotton), Blackgold (Blackgram), PKV-Kranti (*Rabi* sorghum) and Jaki – 9218 (Chickpea). Treatment details were cropping system *viz.* T_1 - Cotton *fb* Pigeonpea + Soybean (1:3), T_2 - Pigeonpea + Soybean (1:4) *fb* Cotton + Blackgram (2:1), T_3 - Blackgram – *rabi* sorghum *fb* Cotton + sunhemp GM (2:1), T_4 - Pigeonpea + Foxtail millet (1:4) *fb* Cotton, T5 - Blackgram – Chickpea *fb* Cotton + Pigeonpea (3:1) and T6 - Cotton *fb* Cotton and three organic integrated nutrient management (OINM) *viz.* N1 - Organic Package (Recommended package) 100% RDN through equivalent organic sources i.e. FYM and Vermicompost (top dressing), N2 - Organic Integrated Nutrient Management (OINM) 75% through FYM and Vermicompost (top dressing) + 25% through Neem cake and N3 - Control (No manure). Complete sowing was done on Broad bed furrow with row to row spacing of 45 cm in first year to all crops except cotton while in second year all crops were sown on row to row spacing of 60 cm. Seed treatment with Bio-fertilizers *Rhizobium, Trichoderma,* PSB and *Azotobacter* was common to all crops. The protein content of various crops was calculated empherically by multiplying the seed N% with a factor of 6.25. Protein yield was determined by using formula,

$$\text{Protein yield (kg ha}^{-1}) = \frac{\text{Protein (\%)} \times \text{Seed yield (kg ha}^{-1})}{100}$$

Result and Discussion

Protein content (%) and protein yield (kg ha^{-1})

Data related to protein content (%) and protein yield (kg ha^{-1}) are given in Table 1 and 2. The protein content mainly depends upon the nitrogen content of seed. During 2018-19 and 2019-20, mean protein content in cotton seed was 13.47 and 13.14, pigeonpea seed was 22.53 and 22.33, blackgram seed was 25.26 and 25.40, soybean seed was 37.67 and 37.81 percent while it was 10.73, 10.75 and 16.92 percent respectively in foxtail millet, *rabi* sorghum and chickpea. Mean protein yield in cotton seed was 145.49 and 149.80, pigeonpea was 196.16 and 178.25, blackgram was 186.43 and 147.38, soybean was 566.71 and 456.28 percent while it was 46.57, 149.94 and 220.95 percent, respectively in foxtail millet, *rabi* sorghum and chickpea.

Cropping sequence

Protein content and protein yield was found highest in pigeonpea + soybean (1:4) in first year and pigeonpea + soybean (1:3) in second year. Protein yield was pointedly influenced by various treatments due to substantial differences among treatments in respect of seed yield. Similar results were reported by Kolpe and Bodake (2017) [2] and Paslawar *et al*. (2007) [4].

Organic integrated nutrient management

Protein content (%) and protein yield (kg ha^{-1}) was found maximum with 75% FYM + Vermicompost (top dressing) + 25% Neem cake, followed by 100% FYM + Vermicompost and least under control. Nitrogen is a basic constituent of protein and with the increase in rate of nitrogen application from organic manures, the nitrogen availability increased which resulted in enhanced protein content in seeds and ultimately protein yield. Nitrogen is a basic constituent of protein and with the increase in rate of nitrogen application from organic manures and inorganic fertilizers, the nitrogen availability increased which resulted in enhanced protein content in seeds and protein yield. Similar results were reported by Kumavat *et al*. (2000) [3], Joshi (2003) [1] and Kolpe and Bodake (2017) [2].

Total Protein yield (kg ha^{-1}) and Quality protein available for individuals per year

Data related to total protein yield (kg ha^{-1}) are given in Table 2 and shown in figure 9. Mean total protein yield (kg ha^{-1}) was 352.43 and 297.13 kg ha^{-1} in first and second year respectively. As per recommendations from Indian Council of Medical Research protein consumption should be about 60 g day^{-1} $person^{-1}$ but the average intake in India is only 31 g day^{-1} (NNMB, 2012). Therefore, calculation of available protein on the basis of 60 g day^{-1} $person^{-1}$ $year^{-1}$ was worked and presented in Table 2. Mean quality available protein was 15.7 and 13.6 $person^{-1}$ $year^{-1}$ in both years of experimentations. But with intercropping of pigeonpea + soybean produced sufficient protein per annum than other systems.

A. Cropping sequence

In both years total protein yield and available quality protein was found highest in pigeonpea + soybean (1:4) and pigeonpea + soybean (1:3) cropping sequence followed by blackgram – chickpea in first year and cotton + blackgram (2:1) in second year over rest of the cropping sequence. As, there were more leguminous crops involved in cropping sequence during first year which replicates in higher total

protein yield (kg ha^{-1}) and ultimately, mean quality available protein person^{-1} year^{-1} over second year.

B. Organic integrated nutrient management: Total protein yield (kg ha^{-1}) and available quality protein was found maximum in 75% FYM + Vermicompost (top dressing) + 25% Neem cake (471.1 kg ha^{-1}) over rest of the organic integrated nutrient management treatments. Similar results were reported by Paslawar *et al*. (2007) [4].

Table 1: Protein content (%) of various crops as influenced by different cropping systems and organic integrated nutrient modules during 2018-19 and 2019-20.

Treatments	2018-19							2019-20			
	Main crop			Intercrop		Sequence crop		Main crop		Intercrop	
Main factor A) Cropping system	**Ct**	**PP**	**BG**	**Soy**	**FM**	**Sorg**	**Ck**	**Ct**	**PP**	**BG**	**Soy**
T_1 – Cotton *fb* PP + Soy (1:3)	13.52								22.44		37.81
T_2 - PP + Soy (1:4) *fb* Ct + BG (2:1)		22.56		37.67				13.52		25.40	
T_3 - BG –Sorg *fb* Ct + GM (2:1)			25.29			10.75		13.88			
T_4 - PP + FM (1:4) *fb* Cotton		22.50			10.73			13.23			
T_5 - BG – Chickpea *fb* Ct + PP (3:1)			25.23				16.92	13.35	22.23		
T_6 – Cotton *fb* Cotton	13.42							13.31			
Sub factor											
B) OINM											
N_1 – FYM + VC	13.91	23.56	26.28	38.44	11.19	11.06	17.19	12.69	22.69	26.06	37.94
N_2 – FYM + VC+ NC	13.59	22.75	25.63	37.56	10.69	10.81	16.94	13.01	23.16	26.56	38.81
N_3 – Control	12.91	21.28	23.88	37.00	10.31	10.38	16.63	12.15	21.16	23.56	36.69
GM	13.47	22.53	25.26	37.67	10.73	10.75	16.92	13.14	22.33	25.40	37.81

Ct – Cotton, PP – Pigeonpea, BG – Blackgram, Soy – Soybean, FM – Foxtail millet, Sorg – *Rabi* sorghum, Ck – Chickpea, Sun (GM) – Sunhemp (Green Manuring)

Table 2: Protein yield (kg ha^{-1}) of various crops as influenced by different cropping systems and organic integrated nutrient modules during 2018-19 and 2019-20.

Treatments	2018-19							2019-20			
	Main crop			Intercrop		Sequence crop		Main crop		Intercrop	
Main factor A) Cropping system	**Ct**	**PP**	**BG**	**Soy**	**FM**	**Sorg**	**Ck**	**Ct**	**PP**	**BG**	**Soy**
T_1 – Cotton *fb* PP + Soy (1:3)	137.27								220.85		456.28
T_2 - PP + Soy (1:4) *fb* Ct + BG (2:1)		215.39		537.14				146.11		147.38	
T_3 - BG –Sorg *fb* Ct + GM (2:1)			188.10			145.26		168.43			
T_4 - PP + FM (1:4) *fb* Cotton		196.72			46.20			146.29			
T_5 - BG – Chickpea *fb* Ct + PP (3:1)			180.63				208.99	138.62	136.65		
T_6 – Cotton *fb* Cotton	132.80							149.55			
Sub factor											
B) OINM											
N_1 – FYM + VC	161.37	250.51	225.20	637.72	53.43	166.46	241.69	171.25	203.14	169.20	528.22
N_2 – FYM + VC+ NC	168.92	248.97	227.19	641.05	53.05	176.68	264.79	184.71	216.59	182.57	584.78
N_3 – Control	74.82	118.70	100.71	332.63	32.11	92.65	120.48	93.44	116.52	90.35	255.83
GM	145.49	196.16	186.43	566.71	46.57	149.94	220.95	149.80	178.75	147.38	456.28

Ct – Cotton, PP – Pigeonpea, BG – Blackgram, Soy – Soybean, FM – Foxtail millet, Sorg – *Rabi* sorghum, Ck – Chickpea, Sun (GM) – Sunhemp (Green Manuring)

Table 3: Total protein yield (kg ha^{-1}) and Protein availability for number of individuals per year as influenced by different cropping systems and organic integrated nutrient modules during 2018-19 and 2019-20.

Treatments	2018-19		2019-20	
Main factor A) Cropping system	**Total protein yield kg ha^{-1}**	**Quality Protein available for number of individuals per year**	**Total protein yield kg ha^{-1}**	**Quality Protein available for number of individuals per year**
T_1 – Cotton *fb* PP + Soy (1:3)	137.27	6.3	677.13	30.9
T_2 - PP + Soy (1:4) *fb* Ct + BG (2:1)	752.53	34.4	293.49	13.4
T_3 - BG –Sorg *fb* Ct + GM (2:1)	333.36	15.2	168.43	7.7
T_4 - PP + FM (1:4) *fb* Cotton	242.92	11.1	146.29	6.7
T_5 - BG – Chickpea *fb* Ct + PP (3:1)	389.62	17.8	275.27	12.6
T6 – Cotton *fb* Cotton	132.80	6.1	149.55	6.8
Sub factor				
B) OINM				
N_1 – FYM + VC	438.66	20.0	368.90	16.8
N_2 – FYM + VC+ NC	443.44	20.2	400.31	18.3
N_3 – Control	217.46	9.9	194.78	8.9
GM	352.43	15.7	297.13	13.6

Conclusion

In both years total protein yield, available quality protein, oil yield and available quality oil was found highest in pigeonpea + soybean (1:4) and pigeonpea + soybean (1:3) cropping sequence followed by blackgram – chickpea in first year and cotton + blackgram (2:1) in second year over rest of the cropping sequence.

However, total protein yield, available quality protein, oil yield and available quality oil was found highest with application of 75% organic integrated nutrients through FYM and vermicompost (top dressing) + 25% through neem cake over other OINM treatments.

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