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Effect of organic and inorganic nutrients on pearl millet (*Pennisetum glaucum*)-gobhi sarson (*Brassica napus* var. napus) cropping sequence

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ABSTRACT

A pronounced residual effect of organic and inorganic nutrients, applied in pearl millet crop was observed on yields of pearl millet [*Pennisetum glaucum* (L.) R Br]-gobhi sarson (*Brassica napus* L. var napus) cropping system. The experiment was conducted (by way of inorganic and organic sources combinations) with 8 treatments of FYM, vermicompost, inorganic N and control. The highest growth, yield and yield parameters of pearl millet crop were recorded with 100% recommended fertilizer dose-RFD and the grain yield (2899 kg/ha) was about 85.2% higher over the control and was followed by statistically similar treatment 75% N inorganic + 25% VC with the grain yield value of 2703 kg/ha. In case of gobhi sarson, the highest grain yield (855 kg/ha) was observed owing to residual effect of 100% N through vermicompost (VC) applied in preceding pearl millet crop, which was about 82.3% higher over the control. The treatments where 50% N was substituted by FYM and VC in pearl millet crop had the statistically similar grain yield values of gobhi sarson. The highest rain water use efficiency (RWUE) and heat-use efficiency (HUE) was recorded in treatment 100% RFD in pearl millet crop and 100% N through VC in gobhi sarson.

Key words: Inorganic fertilizers, Millet based cropping system, Organic manures

Pearl millet [*Pennisetum glaucum* (L.) R BR] is the fifth most important food crop of India next to rice, wheat, maize and sorghum grown predominantly with rainfall moisture. In India, pearl millet is cultivated on about 8.16 mha area with a production and productivity of about 9.56 MTs and 1172 kg/ha, respectively. However, in J&K UT, it is grown on about 20 thousand ha area with production and productivity of about 10 tonnes and 597 kg/ha, respectively (Anonymous 2016). About 12% of the total geographical area of Jammu region constitute dry semi-hilly belt and is locally known as *kandi* area. The area purely rainfed in nature and the most moisture stressed ecosystem of the region (Abrol *et al.* 2007). Pearl millet-gobhi sarson (*Brassica napus* L. var napus) cropping sequence is usually practised by marginal and small farmers of *kandi* belt both under plain and hilly tract of low altitude sub-tropical Jammu region. The conjunctive application of organic with inorganic sources of nutrients reduces the dependence on chemical inputs (Munda *et al*. 2011). Integrated plant nutrient supply system has assumed a great importance and is of vital significance for the maintenance of soil productivity and is the need of hour. Organic manures, particularly FYM and vermicompost not only supply macronutrients (in smaller proportion) but also meet the requirements of micronutrients, besides improving soil health and beneficial microbial activities (Kumar *et al.* 2014). Hence, the present investigation was carried out to study the integrated use of inorganic fertilizers and organic manures on growth, yield, uptake and economics in pearl millet-gobhi sarson cropping sequence.

MATERIALS AND METHODS

The field experiments were conducted at Research Farm, ACRA, Rakh Dhiansar, SKUAST-Jammu, J&K UT (32° 39" N 74° 53" E, 332 m amsl) during *kharif* and *rabi* of 2013–14, 2014–15, 2015–16 and 2016–17 under rainfed conditions. The soil of the experimental site was *Inceptisols* having sandy loam texture with low available nitrogen, medium phosphorus, low potash with *p*H value 6.58 and low organic carbon (2.8 g/kg). The climate of the region represents sub-tropical conditions characterized by hot and dry summer, cold and dry winter and humid *monsoon*. Weather data was recorded at Meteorological Observatory, ACRA, Rakh Dhiansar. The mean maximum and minimum

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temperature recorded in pearl millet crop were in the range of 31.7–34.9ºC and 20.8–25.2ºC, respectively (mean of four years). The mean of total rainfall received during the cropping season was 857.8 mm. However, in gobhi sarson crop mean maximum and minimum temperature recorded were in the range of 16.8–32.2ºC and 5.1–18.8ºC, respectively (mean of four years).

The experiment comprised eight treatments, viz. T_1: Control; T_2: 100% recommended fertilizer dose-RFD (50:30:15 NPK kg/ha); T_3:75% N inorganic + 25% N through FYM, T_4: 50% N inorganic + 50% N through T_5: FYM, 100% N through FYM, T_6: 75% N inorganic + 25% N through vermicompost, T_7: 50% N inorganic + 50% N through vermicompost and T_8: 100% N through vermicompost and each treatment was replicated thrice. The size of the plot was 4.5 m × 4.0 m. Pearl millet (Var Nandi *65*) was sown at onset of monsoon and harvested at the physiological maturity; whereas, gobhi sarson crop (Var DGS-1) was sown on the residual moisture of the receding monsoon in the month of October and harvested in April in their years of sowing. Pearl millet and gobhi sarson crops were sown in lines with spacing of 45 cm × 10 cm and 30 cm × 20 cm, respectively. All the treatments were applied in pearl millet crop and their residual effects were studied in gobhi sarson crop. A total rainfall of 870.0, 659.2 584.7, and 644.1 mm was received during *kharif* and 173.8, 370.3, 118.3 and 165.3 mm during *rabi* in the respective years of cultivation. Urea, DAP and MoP were used as a source of nitrogen, phosphorus and potassium, respectively. Pearl millet equivalent yield (PMEY) was computed by converting the gobhi sarson yield into the yield of pearl millet on the basis of the prevailing market prices of individual crop produce.

The following agro-meteorological indices were calculated:

Accumulated heat unit (∑HU): The accumulated heat units were calculated as (Nuttonson 1955);

$$HU = \frac{\sum_a^b [T\ max + T\ min\ ] - T_b}{2}$$

where T max, Maximum temperature (˚C) during a day; T min, Minimum temperature (˚C) during a day and T_b, Base temperature 8 and 5ºC for pearl millet and gobhi sarson crops, respectively under sub-tropical conditions.

Heat use efficiency (HUE): HUE is the ratio of dry matter (kg/ha) to the cumulative heat unit to attain the physiological maturity.

$$HUE\ (kg/ha/^oC/day) = \frac{Dry\ matter\ (kg/ha)}{Cumulative\ heat\ unit\ (^oC\ days)}$$

RESULTS AND DISCUSSION

Pearl millet: Integrated nutrient management (INM) practices applied to pearl millet crop significantly affected the growth and yield attributing characters. The maximum plant height, no. of tillers/m row length and dry matter accumulation (g/plant) was found with the application of recommended fertilizer dose (100% RFD) applied in *kharif* to pearl millet crop during the four years of experimentation. However, the values were at par with INM treatment where 25% N was replaced with vermicompost. The INM treatments, viz. 75% N inorganic + 25% N FYM and 50% N inorganic + 50% N vermicompost (VC) recorded the values of growth parameters; which were statistically at par; but higher over other INM treatment combinations. INM through VC and FYM along with inorganic sources remained superior to the rest of the treatments as it may have increased the activities of beneficial microorganisms due to increased organic pool in the soil. The findings are in close conformity with Yadav *et al*. (2008). Statistically higher growth attributing characters values were reported in 100% RFD treatment which was more or less statistically similar to INM treatments except control (Table 1).

Gobhi sarson: The application of inorganic and organic sources of nutrients to pearl millet crop significantly increased all the growth and yield attributing characters in gobhi sarson raised as residual crop over the control (Table 1). Addition of organic matter in the form of VC and FYM applied to the preceding pearl millet crop had a positive effect on gobhi sarson. Nutrient substitution through organic sources in the preceding pearl millet improved the growth and yield attributing parameters of gobhi sarson crop. The values for various growth and yield attributing characters statistically differed for residual effects of the various treatments imposed in preceding pearl millet crop during four years of experimentation. The treatment where 100% N was supplied through VC evinced significantly higher values of all growth and yield attributing characters and was followed by statistically similar values of all the parameters received with the treatment where 100% N was supplied through FYM. It may be due to presence of highly persistent material, i.e. cellulose in VC and FYM which required longer time for complete decomposition. Thus nutrients released from VC and FYM for longer period had notable benefits on the succeeding gobhi sarson crop. These results are in the line with those of Panwar (2008). Improvement in growth and yield attributing parameters of gobhi sarson may also be due to combined application of inorganic fertilizer and organic manure (applied in pearl millet) which might assisted in controlled release of nutrients in the soil through mineralization of organic manures which might have facilitated better crop growth (Katkar *et al.* 2011).

Yield: INM with VC/FYM and their combinations with inorganic fertilizers partially or alone significantly influenced the grain and stover yields of pearl millet crop. The application of 100% NPK (inorganic) recorded statistically higher grain and stover (2899 and 6094 kg/ha) yields of pearl millet which was 85.2 and 44.9% higher control, respectively. However, among INM treatments; 75% N inorganic + 25% N through VC recorded significantly higher grain and stover (2703 and 5996 kg/ha) yields, respectively which was followed by statistically similar treatments 50%

Table 1 Effect of INM on growth and yield attributing characters of pearl millet and gobhi sarson (pooled mean of 4 years)

Treatment	Pearl millet						Gobi sarson						
	Plant height (cm)	No of tillers/m row length	Dry matter accumulation (g/plant)	Length of ear head (cm)	Ear girth (cm)	Test-weight (g)	Plant height (cm)	Primary branches	Secondary branches	Pod-length (cm)	Seeds/ pod	Pods/ plant	Test-weight (g)
Control	207	20.33	53.28	21.42	10.15	9.95	134	7.93	9.47	6.46	18.27	271	3.18
100% NPK	233	35.67	81.28	24.68	12.11	13.12	143	8.52	12.23	6.68	19.97	326	3.60
75% N inorganic + 25%N FYM	223	30.75	78.08	23.94	11.18	12.15	147	8.97	12.96	6.83	20.45	353	3.83
50% N inorganic + 50% N FYM	217	28.42	74.41	22.82	11.05	11.72	149	9.62	14.78	7.08	21.10	370	4.16
100% N through FYM	213	25.42	68.17	22.50	10.85	11.38	154	10.49	17.28	7.43	22.80	427	4.48
75% N inorganic +25% N VC	229	34.08	80.82	24.22	11.63	12.88	147	9.59	13.62	7.07	20.94	395	3.97
50% N inorganic + 50% N VC	224	30.58	79.31	23.52	11.32	12.63	152	10.19	15.47	7.28	21.67	423	4.31
100% N through VC	218	27.67	70.01	22.94	11.00	11.92	159	10.97	18.53	7.48	23.42	469	4.73
LSD (P=0.05)	4.05	2.88	2.02	1.46	0.66	0.75	6.74	0.52	2.29	0.26	151	44.15	0.41

N inorganic + 50% N through VC and 75% N inorganic + 25% N through FYM with the grain yield values to the tune of 2531 and 2526 kg/ha, respectively. The grain and stover yield values of pearl millet crop in the treatments where 100% N was supplied through VC and FYM were statistically significant (Table 2). The higher yield in 100% N through inorganic treatment may be ascribed to the fact that inorganic fertilizers supplied the essential nutrients quickly to the standing crop and are easily available to the crop plants for its better growth and development. The improved performance of INM treatments may be due to the fact that organic manures like FYM and VC increased the microbial biomass content, soil enzyme activities and net mineralization of organic N due to which INM treatments also have performed well. Jaga and Tripathi (2011) also reported similar results.

The grain and stover yield differed statistically for residual effects of the various treatments imposed in preceding pearl millet crop (Table 2). The application of 100% N through VC recorded statistically highest grain and stover (855 and 2849 kg/ha) yield of gobhi sarson which were statistically similar with 100% N through FYM. The beneficial residual effect of VC and FYM may be due to its contribution in supplying additional plant nutrients, improvement of soil physical and biological processes. Kumar *et al*. (2014) also recorded similar results for pearl millet and wheat crops.

The system productivity in terms of pearl millet equivalent yield (PMEY) was significantly influenced by different inorganic and organic nutrients alone or in combinations. The maximum PMEY (4366 kg/ha) was obtained in 100% N through VC followed by PMEY values of 4344 and 4328 kg/ha recorded with 50% N inorganic + 50% N through VC and 75% N inorganic + 25% N through VC, respectively. This may be due to the fact that efficiency of inorganic fertilizers increased when these are used in conjunction with organic manures (Table 2). The results are in line with Gupta *et al*. 2014. The organic sources enhanced the efficient utilization of the native as well as added fertilizer nutrients, which maintained balance between growth and yield attributes.

Rain water use efficiency (RWUE): The statistically higher values of RWUE (4.26 kg/ha-mm) of pearl millet was recorded in 100% NPK treatment which was followed by RWUE values to the tune of 3.99, 3.76 and 3.74 kg/ha-mm in treatments 75% N inorganic + 25% N-VC, 50% N inorganic + 50% N-VC and 75% N inorganic + 25% N-FYM, respectively. However, in case of gobhi sarson crop, where 100% N was substituted through VC registered significantly higher value of RWUE (4.82 kg/ha-mm) which was followed by statistically similar treatments 100% N-FYM (4.68 kg/ ha-mm) and 50% N inorganic + 50% N-VC (4.36 kg/ ha-mm) (Table 2). Gupta *et al.* (2014) observed more or less similar results in case of maize-gobhi sarson cropping system under rainfed areas of Jammu region.

Economics: Highest mean value of net returns (₹ 43438/ ha) and B:C ratio (1.61) were recorded in 100% NPK

Table 2 Effect of organic and inorganic nutrients on yield (kg/ha), economics and nutrient uptake of pearl millet and gobhi sarson under rainfed conditions (Pooled mean of 4 years)

Treatment	Pearl millet		Gobhi sarson		PMEY	RWUE (kg/ha-mm)		Economics		Nutrient uptake					
										Pearl millet			Gobhi sarson		
	Grain	Stover	Grain	Stover		Pearl millet	Gobhi sarson	Net returns (₹/ha)	B:C ratio	N	P	K	N	P	K
Control	1565	4204	469	1912	2672	2.31	2.57	18714	0.75	41.75	6.24	37.66	16.98	5.96	14.10
100% NPK	2899	6094	604	2265	4324	4.26	3.28	43438	1.61	84.00	13.77	67.71	26.18	8.14	18.99
75% N inorganic + 25% N FYM	2526	5766	640	2450	4037	3.74	3.51	37733	1.35	70.48	11.15	56.95	29.50	8.65	20.89
50% N inorganic + 50% N FYM	2356	5695	724	2643	4067	3.49	4.06	36912	1.26	64.70	10.14	53.86	34.20	10.08	22.76
100% N through FYM	2147	5413	823	2753	4091	3.16	4.63	36287	1.23	57.42	8.82	49.35	39.29	11.68	26.07
75% N inorganic +25% N VC	2703	5996	688	2539	4328	3.99	3.85	40838	1.39	79.43	12.56	64.53	32.86	9.61	22.21
50% N inorganic + 50% N VC	2531	5835	767	2716	4344	3.76	4.36	38172	1.19	72.62	11.39	60.23	37.04	10.68	25.02
100% N through VC	2347	5612	855	2849	4366	3.46	4.82	35378	1.03	61.37	9.70	55.60	41.04	12.17	27.69
LSD (P=0.05)	190.4	309.8	89	316	250	0.21	0.53			4.43	0.93	3.52	6.19	1.83	3.65

PMEY, Pearl millet equivalent yield; RWUE, Rain water use efficiency

treatment (Table 2). This treatment gave 132.1 and 114.7% higher net returns and B:C ratio over control, respectively. Among the INM treatments; 75% N inorganic + 25% N-VC evinced highest values of net returns (₹ 40438/ha) and B:C ratio (1.39) which was followed by the treatments 50% N inorganic + 50% N-VC and 75% N inorganic + 25% N-FYM. However, the B:C ratio was higher in treatment 75% N inorganic + 25% N-FYM because of lower cost of FYM than vermicompost.

Nutrient uptake: In pearl millet crop, a prominent variation in uptake of NPK was observed. However, significantly highest NPK uptake by pearl millet crop was recorded in 100% NPK treatment (84.0, 13.77 and 67.71 kg/ha), respectively. Among the INM treatments, the highest NPK uptake was observed with 75% N inorganic + 25% N-VC (79.43, 12.56 and 64.53 kg/ha) which was immediately followed by statistically dissimilar treatment 50% N inorganic + 50% N-VC with the NPK uptake values of 72.62, 11.39 and 60.23 kg/ha in pearl millet crop, respectively. However, in case of gobhi sarson, statistically higher values of NPK uptake were recorded in 100% N-VC (41.04, 12.17 and 27.69 kg/ha) which were followed by statistically at par treatments 100% N-FYM (39.29, 11.68 and 26.07 kg/ha) and 50% N inorganic + 50% N-VC with the NPK uptake values to the tune of 37.04, 10.68 and 25.02 kg/ha, respectively (Table 2). This could be attributed to better residual effect of VC and FYM in terms of slow but steady supply of nutrients. The increase in NPK uptake due to organic sources applied has further been accounted to greater multiplication of soil microbes. These findings are in line with the results of Abrol *et al*. (2007).

Heat use efficiency: The highest grain yield heat use efficiency (GYHUE) in pearl millet crop was found to be 1.65 kg/ha/^{o}C/day which was observed in 100% NPK, followed by GYHUE values 1.54 and 1.44 kg/ha/^{o}C/day in treatment 75% N inorganic + 25% N-VC and 50% N inorganic + 50% N-VC; however the treatment 75% N inorganic + 25% N-FYM shared statistically similar values of GYHUE (1.44 kg/ha/^{o}C/day) with treatment 50% N inorganic + 50% N-VC (Fig 1). Maximum GYHUE value (0.35 kg/ha/^{o}C/day) in gobhi sarson crop was found in 100% N-VC followed by 0.34 and 0.31 kg/ha/^{o}C/day in 100% N-FYM and 50% N inorganic + 50% N-VC, respectively. The biological yield heat use efficiency (BYHUE) of pearl millet and gobhi sarson crops followed the similar trend as that of GYHUE. The combination of various organic and inorganic nutrients affected the dry matter accumulation in pearl millet and gobhi sarson crops due to which different values of GYHUE and BYHUE values of both the crops were obtained.

On the basis of 4 years of experimentation, INM through 75% N inorganic + 25% N through VC significantly improved productivity, RWUE, GYHUE and BYHUE, recorded relatively higher nutrient uptake, improved soil health and proved itself to be economically superior as compared to most of the treatments except for that of purely inorganic fertilizer application.

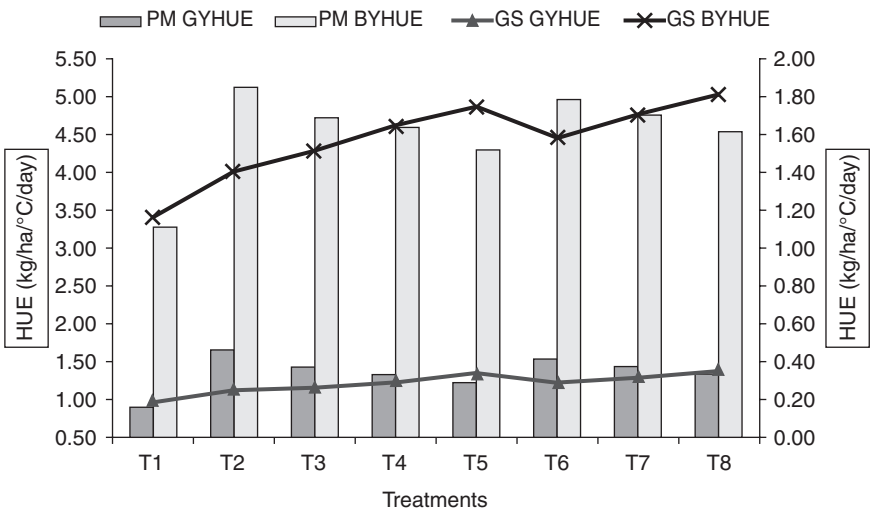

Fig 1 Heat-use efficiency (HUE) of grain and biological yields of pearl millet and gobhi sarson crops as affected by integrated nutrient management (mean of 4 years).

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