

Effect of enriched organic formulations on productivity and profitability of baby corn (*Zea mays*)–kabuli gram (*Cicer arietinum*)–vegetable cowpea (*Vigna unguiculata*) cropping system in a semi-arid agro-ecology

KAMAL GARG¹, SHIVA DHAR², ANCHAL DASS³, V.K. SHARMA⁴,
RAJENDRA PRASAD MEENA⁵ AND SHANTI DEVI BAMBORIYA⁶

ICAR-Indian Agricultural Research Institute, New Delhi 110 012

Received: May 2022; Revised accepted: August 2022

ABSTRACT

A field experiment was conducted during 2020–21 and 2021–22 at the research farm of ICAR-Indian Agricultural Research Institute, New Delhi, to evaluate the productivity and profitability of baby corn (*Zea mays* L.)–kabuli gram (*Cicer arietinum* L.)–vegetable cowpea [*Vigna unguiculata* (L.) Walp.] cropping system as influenced by enriched organic formulations. Seven nutrient sources, viz. control, 100% recommended dose of nitrogen (RDN) through FYM, 100% RDN through improved rice residue compost (RRC), 100% RDN through paddy husk ash (PHA)-enriched FYM, 75% RDN through paddy husk ash (PHA)-enriched FYM, 100% RDN through potato (*Solanum tuberosum* L.) peel compost (PPC)-enriched FYM and 75% RDN through potato peel compost (PPC)-enriched FYM were tested in randomized block design with 3 replications. Results showed that, application of 100% RDN through paddy husk ash (PHA)-enriched FYM gave significantly highest yield of baby corn (1.6 and 1.6 t/ha corn, 8.7 and 8.8 t/ha cob and 25.6 and 26.4 t/ha green fodder), kabuli gram (2.8 and 2.9 t/ha seed and 4.4 and 4.5 t/ha stover) and vegetable cowpea (10.9 and 11.0 t/ha green pod and 24.4 and 24.9 t/ha stover), followed by 100% RDN through potato peel compost (PPC)-enriched FYM and FYM during both the years of study. System productivity in terms of baby corn-equivalent yield (BCEY) was significantly higher under 100% RDN through paddy husk ash (PHA)-enriched FYM (8.7 and 9.0 t/ha) during both the years. This treatment resulted in statistically highest net returns (₹ 553.6 × 10³/ha and ₹ 567.8 × 10³/ha) and benefit : cost ratio (5.0 and 4.9) during 2020–21 and 2021–22, respectively, and remained at par with 100% RDN through potato peel compost (PPC)-enriched FYM and FYM during both the years.

Key words: Farmyard manure, Net returns, Paddy husk ash, Potato peel compost, System productivity

India has made spectacular breakthrough in production and consumption of fertilizers during the last 4 decades. However, the imbalanced and continuous use of chemical fertilizers in intensive cropping system has led to reduction in the crop yields and resulted in imbalance of nutrients in soil which has adverse effect on soil physico-chemical properties. Due to the drastic rise in prices for commercial fertilizers, search for alternative sources of plant nutrients has become increasingly important, particularly for re-

source-poor farmers of South Asia. No doubt, the use of chemical fertilizers is the quickest way of boosting crop production but their increasing prices, soil-health deterioration, sustainability and pollution considerations in general have led to renewed interest in the use of organic manures. Use of organics build up the soil humus, improving the soil physical and biological properties. Therefore, organic nutrient-management systems are needed to maintain agricultural productivity and protect the environment.

Regular additions of organic materials such as, municipal biosolids, animal manures, crop residues and agro-industrial wastes are of utmost importance in maintaining the fertility and productivity of agricultural soils (Solaimalai *et al.*, 2001). Moreover, raw materials required to make FYM are easily available to farmers. Thus, preparation of farmyard manure and use the same may be economical as well as easy. It has been reported that, the prolonged application of FYM makes nutrients available gradually and

Based on a part of Ph.D. Thesis of the first author, submitted to the Indian Agricultural Research Institute, New Delhi in 2022 (unpublished)

¹Corresponding author's Email: kamalgarg1256@gmail.com

¹Ph.D. Scholar, ^{2,3,4}Principal Scientist, ICAR-Indian Agricultural Research Institute, New Delhi 110 012; ⁵Scientist, ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan (VPKAS), Almora Uttarakhand 263 601, ⁶Scientist, ICAR-Indian Institute of Maize Research, Ludhiana, Punjab 141 004

synchronize with the needs of plant. The conversion of rice (*Oryza sativa* L.) straw into value-added compost may have the potential to improve productivity of the crops and reduce the environmental pollution as well as loss of plant nutrients and organic matter. There is a need to utilize rice straw as a source of plant nutrients and organic matter to improve soil productivity. Composting of these residues and their application may minimize this huge wastage of organic matter. Ashes from combustion of biomass are the oldest mineral fertilizers in the world (Schiemenz and Eichle-Loebermann, 2010). Biomass ashes are nearly free of N but contain significant quantities of P, K, Ca, Mg and micronutrients essential for plant nutrition (Bhattacharya and Chattopadhyay, 2002). Biomass materials, viz. bagasse, rice husk, rice straw etc. (~500 million metric tonnes per year) have been used for power generation owing to their potential as an energy source. The recycling of biomass ashes in agriculture may solve the problem of their disposal as well as reduce the doses of commercial fertilizer application (Bougnom and Insam, 2009). Potato (*Solanum tuberosum* L.) peel is not only a household waste as small-scale industries and fast-food companies are also dealing with an ever-increasing number of potato peel waste. The potato peel manure is very useful for farmers because it gradually increases NPK content in the soil.

Therefore, to make the nutrient-management system the most efficient, the practical way is to mobilize all the available, accessible and affordable plant nutrient from various sources in order to optimize the productivity of the system. The integration of organic manures and composts of residues of various crops available with farmers would be able to maintain soil fertility as well as sustain crop productivity. Hence, present investigation was conducted with the objective to find out the effect of enriched-organic formulations on productivity and profitability of baby corn (*Zea mays* L.)–kabuli gram (*Cicer arietinum* L.)–vegetable cowpea [*Vigna unguiculata* (L.) Walp.] cropping system for achieving high yield and economics.

MATERIALS AND METHODS

A field experiment was conducted during 2020–21 and 2021–22 at the research farm of Indian Agricultural Research Institute, New Delhi (28.38° N, 77.09° E and at 228.6 m above mean sea-level), in north western India. The soil of the experimental site was sandy clay loam (sand 63.8%, silt 12.2% and clay 24.0%) with pH 8.1 and electrical conductivity 0.36 dS/m in the top 15 cm. The soil was low in available nitrogen (206.2 kg/ha) and organic carbon (0.37%), medium in available phosphorus (13.6 kg/ha) and potassium (236.0 kg/ha). Higher and relatively well-distributed rainfall was received during 2021–22 as

compared to 2020–21. The total rainfall received during July–May was 913.6 and 1682.9 mm during 2020–21 and 2021–22 respectively. The experiment comprised of 1 cropping system (baby corn–kabuli gram–vegetable cowpea) and 7 nutrient sources, viz. control, 100% recommended dose of nitrogen (RDN) through FYM, 100% RDN through improved rice residue compost (RRC), 100% RDN through paddy husk ash (PHA)-enriched FYM, 75% RDN through paddy husk ash (PHA)-enriched FYM, 100% RDN through potato peel compost (PPC)-enriched FYM and 75% RDN through potato peel compost (PPC)-enriched FYM were tested in randomized block design with 3 replications. The improved rice residue compost (RRC), paddy husk ash (PHA)-enriched FYM and potato (*Solanum tuberosum* L.) peel compost (PPC)-enriched FYM were prepared in Biomass Utilization Unit, IARI New Delhi. The plot size was 5.0 m × 4.5 m for each treatment. Baby corn variety ‘G 5414’, kabuli gram cultivar ‘Pusa 3022’ and vegetable cowpea variety ‘Pusa Komal’ were taken in the experiment. The RDN of baby corn, kabuli gram and vegetable cowpea were 150, 20 and 20 kg N/ha respectively. The contents of organic formulations were multiplied by the quantity of that material for calculating the quantity of organic formulations added through different material. Organic nutrient sources were applied before sowing/planting of crops based on the nitrogen-equivalent basis and nutrient requirement of each crop in respective treatment. The farmyard manure, rice residue compost and potato peel compost contained 0.72, 0.55 and 0.61% N during 2020–21, and 0.70, 0.58 and 0.59% N during 2021–22 respectively. Baby corn was sown in the first week of July and harvested in the second week of September. Kabuli gram was sown in the first week of October and harvested in the first week of March. Vegetable cowpea was planted in the first week of March and harvested in the third week of May during both the years of experimentation. After harvesting, threshing, cleaning and drying, the seed yield of crops were estimated. Likewise, stover yield was recorded by subtracting seed yield from the total biomass yield. Yield was expressed in t/ha. Economic yield of the component crops were converted to baby corn-equivalent yield (BCEY), taking into account the prevailing minimum support price (MSP)/market prices of the crops. System productivity was calculated by adding the BCEY of the component crops. Prevailing market prices of inputs as per treatments of each crop was considered for working out the cost of cultivation. Production efficiency in economic terms was calculated by taking system gross returns, net returns and benefit : cost ratio. The data obtained from study for 2 years were analysed statistically using the F-test, as per the procedure given by Gomez and Gomez (1984). LSD values at $P = 0.05$ were used to deter-

mine the significance of difference between treatment means.

RESULTS AND DISCUSSION

Yield

Baby corn: An appraisal of data presented in Table 1 clearly indicated that, all the enriched organic formulations resulted in significantly higher baby corn yield than the control during both the years. Significantly higher yield of baby corn (1.6 and 1.6 t/ha), cob (8.7 and 8.8 t/ha) and green fodder yield (25.6 and 26.4 t/ha) was recorded under treatment receiving 100% RDN through PHA-enriched FYM over the control, followed by 100% RDN through PPC-enriched FYM and FYM during both the years (Table 1). Similarly, an application of 100% RDN through improved RRC being at par with 75% RDN through PHA-enriched FYM and PPC-enriched FYM also increased the baby corn yield (without and with husk) and green fodder to the tune of 41.3, 47.4 and 24.7% during 2020–21 and 45.1, 45.5 and 28.4% over the control during 2021–22 respectively. The increase in yield might be owing to increase in yield parameters of baby corn such as length of baby corn, weight of baby corn and number of cobs/plant. The increase in green fodder yield of baby corn recorded in this treatment was attributed to increase in plant height, number of leaves, leaf-area index and total dry-matter production. These results are in conformity with the findings of Naganagouda (2001). The highest baby corn yield was registered under PHA enriched FYM because of relatively higher annual carbon and nutrient inputs in treatments involving FYM which ensued good fruiting ability that resulted higher cobs per plant and ultimately higher yield.

Kabuli gram: Data pertaining to yields (seed and stover) as influenced by enriched organic formulations are given in Table 1. The kabuli gram seed (2.8 and 2.9 t/ha) and stover yield (4.4 and 4.5 t/ha) remained significantly highest under 100% RDN through PHA-enriched FYM during both the years. The treatments, 100% RDN through PPC-enriched FYM and FYM, remained next in order in respect of seed and stover yield of kabuli gram. Application of 100% RDN through PHA-enriched FYM enhanced the seed yield of kabuli gram to the tune of 44.3% during 2020–21 and 45.7% during 2021–22 over the control, respectively. Since the nitrogen requirement of kabuli gram is low and it grows slowly during the winter season, it was more responsive to organic source, which made the nutrients slowly available for longer time to the crop (Ramesh *et al.*, 2009) which in turn increased growth and yield. The beneficial response of FYM in conjunction with PHA to yield might be owing to the availability of sufficient amounts of plant nutrients throughout the growth period and especially at critical

Table 1. Effect of enriched organic formulations on yields of baby corn–kabuli gram–vegetable cowpea cropping system

Treatment	Baby corn						Kabuli gram						Vegetable cowpea								
	Baby corn yield (t/ha)			Cob yield with husk (t/ha)			Green fodder yield (t/ha)			Seed yield (t/ha)			Stover yield (t/ha)			Green pod yield (t/ha)			Stover yield (t/ha)		
	2020–21		2021–22	2020–21		2021–22	2020–21		2021–22	2020–21		2021–22	2020–21		2021–22	2020–21		2021–22	2020–21		2021–22
	2020–21	2021–22		2020–21	2021–22		2020–21	2021–22		2020–21	2021–22		2020–21	2021–22		2020–21	2021–22		2020–21	2021–22	
Control	0.9	1.0		4.9	5.0		17.0	17.2		1.9	2.0		3.1	3.2		8.2	8.4		17.4	17.8	
FYM	1.5	1.6		8.1	8.2		24.7	25.2		2.8	2.8		4.4	4.5		10.5	10.7		23.2	23.5	
Improved RRC	1.3	1.4		7.2	7.3		21.2	22.1		2.4	2.4		3.7	3.9		9.6	9.8		21.3	21.6	
PHA-enriched FYM	1.6	1.6		8.7	8.8		25.6	26.4		2.8	2.9		4.4	4.5		10.9	11.0		24.4	24.9	
(100 RDN)																					
PHA-enriched FYM	1.2	1.3		6.9	7.1		21.0	21.9		2.3	2.4		3.7	3.9		9.6	9.7		21.1	21.4	
(75 RDN)																					
PPC-enriched FYM	1.6	1.6		8.3	8.4		25.0	25.9		2.8	2.8		4.4	4.5		10.6	10.8		23.5	23.8	
(100 RDN)																					
PPC-enriched FYM	1.1	1.2		6.5	6.7		20.6	21.0		2.3	2.4		3.7	3.8		9.5	9.7		20.7	20.9	
(75 RDN)																					
SEm±	0.1	0.1		0.3	0.3		1.1	1.0		0.1	0.1		0.2	0.2		0.4	0.4		1.0	0.9	
CD (P=0.05)	0.2	0.2		1.0	0.9		3.3	3.0		0.4	0.3		0.6	0.6		1.3	1.2		3.1	2.9	

FYM, Farmyard manure; RRC, rice residue compost; PHA, paddy husk ash; PPC, potato peel compost; RDN, recommended dose of nitrogen

growth periods of crops resulting in better uptake, plant vigour and yield.

Vegetable cowpea: Application of enriched organic formulations had significant influence on yields of vegetable cowpea during both the years (Table 1). Significantly higher green pod (10.9 and 11.0 t/ha) and stover yield (24.4 and 24.9 t/ha) was recorded under treatment receiving 100% RDN through PHA-enriched FYM over the control followed by 100% RDN through PPC-enriched FYM and FYM during both the years (Table 1). Similarly, application of 100% RDN through improved RRC being at par with 75% RDN through PHA-enriched FYM and PPC-enriched FYM also increased the green pod yield to the tune of 17.2 and 16.2% over the control during 2020–21 and 2021–22 respectively. The increase in green pod yield might be owing to adequate quantities and balanced proportions of plant nutrients supplied to the crop as per need during the growth period, resulting in favourable increase in yield indices which ultimately leads towards an increase in green pod yield. Improved physico-chemical properties of the soil through the application of organic formulations might be the other possible reason for their higher productivity.

System productivity

The yield of component crops of the system expressed as baby corn-equivalent yield (BCEY) under various enriched organic formulations is presented in Table 2. Among the treatments, application of 100% RDN through PHA enriched FYM registered significantly highest BCEY (6.7 and 6.8 t/ha) over other treatments which was statistically at par with 100% RDN through PPC-enriched FYM and FYM during both the years. However, the treatment receiving 100% RDN through improved RRC were also found statistically similar to 75% RDN through PHA-enriched FYM and PPC-enriched FYM during both the years

(Table 2). The application of 100% RDN through PHA-enriched FYM increased the BCEY to the extent of 42.9% during 2020–21 and 42.1% during 2021–22, respectively over the control. This might be owing to balanced supply of nutrients to the crops throughout the crop-growth period, as FYM undergoes decomposition during which series of nutrient transformation takes place and helps in their higher availability to the crops. Higher uptake of nutrients by the crops will result in higher yield.

System economics

Production economics of cropping systems under various enriched organic formulations are given in Table 2. Application of 100% RDN through PHA-enriched FYM resulted in significantly maximum system gross returns ($₹ 671.7 \times 10^3/\text{ha}$ and $₹ 689.6 \times 10^3/\text{ha}$ during 2020–21 and 2021–22 respectively), net returns ($₹ 553.6 \times 10^3/\text{ha}$ and $₹ 567.8 \times 10^3/\text{ha}$ during 2020–21 and 2021–22 respectively) and benefit : cost ratio (5.0 and 4.9 during 2020–21 and 2021–22 respectively), which remained statistically similar to 100% RDN through PPC-enriched FYM and FYM during both the years. However, the treatment receiving 100% RDN through improved RRC were also found statistically similar to 75% RDN through PHA-enriched FYM and PPC-enriched FYM with regard to gross and net returns of system during both the years. It might be because of higher yield obtained from FYM coupled with relatively lower cost of FYM during both the years which had increased the net returns during both the years of experimentation.

It can be concluded that application of organic nutrient sources at 100% recommended dose of nitrogen through paddy husk ash (PHA)-enriched FYM proved optimum for achieving higher productivity and profitability in baby corn–kabuli gram–vegetable cowpea cropping system.

Table 2. Effect of enriched organic formulations on system productivity and economics of baby corn–kabuli gram–vegetable cowpea cropping system

Treatment	Baby corn-equivalent yield (BCEY) (t/ha)		Total cultivation cost ($\times 10^3$ ₹/ha)		Gross returns ($\times 10^3$ ₹/ha)		Net returns ($\times 10^3$ ₹/ha)		Benefit: cost ratio	
	2020–21	2021–22	2020–21	2021–22	2020–21	2021–22	2020–21	2021–22	2020–21	2021–22
Control	6.1	6.3	88.8	91.6	445.6	459.9	356.8	368.3	4.1	4.1
FYM	8.4	8.7	115.2	118.7	643.3	659.4	528.1	540.6	4.9	4.8
Improved RRC	7.4	7.8	123.3	124.4	569.9	589.0	446.5	464.7	3.9	4.0
PHA-enriched FYM (100 RDN)	8.7	9.0	118.1	121.8	671.7	689.6	553.6	567.8	5.0	4.9
PHA-enriched FYM (75 RDN)	7.3	7.7	110.8	114.2	557.8	580.6	447.1	466.4	4.3	4.3
PPC-enriched FYM (100 RDN)	8.5	8.7	116.1	119.8	653.1	670.0	537.0	550.3	4.9	4.8
PPC-enriched FYM (75 RDN)	7.2	7.4	109.3	112.7	541.6	558.4	432.3	445.7	4.2	4.2
SEm±	0.2	0.2	-	-	12.2	12.1	12.2	12.1	0.1	0.1
CD (P=0.05)	0.7	0.7	-	-	37.6	37.4	37.6	37.4	0.4	0.4

FYM, Farmyard manure; RRC, rice residue compost; PHA, paddy husk ash; PPC, potato peel compost; RDN, recommended dose of nitrogen

REFERENCES

- Bhattacharya, S.S. and Chattopadhyay, G.N. 2002. Increasing bioavailability of phosphorus from fly ash through vermicomposting. *Journal of Environmental Quality* **31**(6): 2,116–2,119.
- Bougnom, B.P. and Insam, H. 2009. Ash additives to compost affect soil microbial communities and apple seedling growth. *Die Bodenkultur* **60**(2): 5–15.
- Gomez, K.A. and Gomez, A.A. 1984. Statistical Procedure for Agricultural Research. *An International Rice Research Institute Book*, A. Wiley-inter Science, John Wiley and Sons Inc. New York, United States of America.
- Naganagouda, H. 2001. Response of *kharif* pop sorghum [*Sorghum bicolor* (L.) Moench] genotypes to integrated nutrient management in black soil under rainfed conditions. M.Sc. (Agriculture) Thesis, University of Agricultural Sciences, Dharwad, Karnataka (unpublished).
- Ramesh, P., Panwar, N.R., Singh, A.B. and Ramana, S. 2009. Production potential, nutrient uptake, soil fertility and economics of soybean (*Glycine max*)-based cropping systems under organic, chemical and integrated nutrient management practices. *Indian Journal of Agronomy* **54**(3): 278–283.
- Schiemenz, K. and Eichle-Loebermann, B. 2010. Biomass ashes and their phosphorus fertilizing effect on different crops. *Nutrient Cycling in Agroecosystems* **87**(3): 471–482.
- Solaimalai, A., Baskar, M., Ramesh, P.T. and Ravisankar, N. 2001. Utilization of press mud as soil amendment and organic manure – A review. *Agricultural Reviews* **22**(1): 25–32.