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Integrated nutrient management for enhancement of productivity, profitability and nutrient usages in cauliflower-onion system

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ABSTRACT

The cauliflower-onion system is gaining popularity in urban and semi-urban areas for various reasons. Nutrient management in the system mode of intensive vegetable production is crucial for better growth and higher vegetable productivity. Integration with organic sources has been advocated for predominant systems along with inorganic nutrient sources. However, the information regarding vegetable crops on the subject is scanty. Hence, a study was conducted for two years in the Cauliflower-Onion system with treatments of only recommended dose of fertilizers (RDF), green manuring (GM) with RDF, farm yard manure (FYM 10 t ha^{-1}), GM, FYM and biofertilizers in recently released high yielding varieties of cauliflower (Pusa Shukti, Pusa Paushja) and onion (Pusa Riddhi and Pusa Madhavi). The results revealed that green manuring along with RDF resulted in maximum curd yield of cauliflower for Pusa Shukti (34.3 and 35.0 t ha^{-1}) and Pusa Paushja (30.1 & 30.2 t ha^{-1}), onion bulb yield in Pusa Riddhi (31.5 & 30.1 t ha^{-1}) and Pusa Madhavi (25.6 & 25.1 t ha^{-1}) during 2017 and 2018 respectively. Also, the higher net return, production efficiency, and profitability were recorded under green manuring with RDF. The overall increase in onion bulb yield of Pusa Riddhi and Pusa Madhavi was 10.8 and 14.5 %. In comparison, cauliflower was even higher to the tune of 23.86% (Pusa Shukti) and 19.76 % (Pusa Paushja) under GM+RDF over RDF, respectively.

Keywords: Economics, Integrated nutrient management, Nutrient uptake, Onion, Cauliflower

INTRODUCTION

The production of vegetables has increased from 58.5 million tonnes to 191.7 million tonnes since 1991-92 to 2019-20 and India became second-largest producer of vegetables in the world (Anonymous, 1). It is also a fact that the vegetable crops are more productive than other crops, which have potential of providing more food per unit of time and land area. The vegetable crops are rich in dietary micronutrients and health beneficial phytochemicals which make them 'protective food' and emphasize their role in addressing widespread problem of malnutrition and public health in the country (Singh *et al*., 9). The phytochemicals in vegetables diversify taste and flavour in the cooked foods which contribute to the intake of adequate food by influencing consumers' preferences. However, the calculated per capita gross availability of vegetables is 378 g/day whereas per capita net availability of vegetable (25% loss + 5% exports and processing) is 286 g/day. For good health and balanced nutrition, the daily intake of vegetables should be 300 g per capita; this should have a combination of 125g leafy vegetables, 75g other vegetables, and 100 g root per person every day (ICMR, 3). The predominant cereal-based cropping system is India's mainstay, but a key step to the economic growth of Indian farmers will be to diversify their cereal-based production system and the inclusion of horticultural cash crops in cropping sequences to achieve higher productivity and profitability. Vegetables are an excellent choice of cash crops as they are short-duration, easy to grow, increase cropping intensity, produce good yields, and generate higher prices in market compared to cereals. The vegetable crops are comparatively far superior in terms of productivity values (₹135000/ha) to other combinations such as sugarcane (₹78038/ha), oilseeds (₹26098/ha), pulses (₹12897/ha), and cereals (₹19470/ha) (Vanitha *et al.*, 11). Presently, the productivity of vegetable crops in India is 17 t/ha against the world's productivity (19.6 t/ha), but we need to attain the productivity levels of 25 t/ha to meet the projected demand of 350 million tonnes by 2050. There are many reasons for low vegetable productivity which includes obsolete varieties, non-availability of superior varieties, poor weed, insect pest, diseases, water and nutrient management. Over the past three decades, additional nutrients applied as fertilizer have been responsible for 55 percent of the increase in the yield of food and fiber crops in developing countries. Hence, amongst all reasons for low vegetable productivity, inadequate nutrient management is one of the most important reasons. Intensive cultivation led to the depletion of nutrient stocks in the soil, which has been reached to a hidden

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form of land degradation. Vegetable crops are high-yielding and respond very well to judicious nutrient management. Micronutrients have a special role in improving the quality and yield of vegetable crops. Hence, only dependence on inorganic fertilizer is not sustainable nutrient management. Many workers have reported enhanced vegetable and seed quality by chemical fertilizers integrated with vermicompost and bio-fertilizers (Kanwar *et al*., 6). In the present scenario of declining soil organic carbon, integrated nutrient management including both inorganic and organic sources will help in sustaining soil health, better crop growth and higher productivity. In this background, the organic sources like green manuring, FYM, biofertilizers were tested along with recommended fertilizers (RDF) doses for promising cultivars of cauliflower-onion system under semi-arid conditions of Trans Indo Gangetic plain zones.

MATERIALS AND METHODS

The field experiments were conducted at Research Farm, Top Block, (TB4E), ICAR-Indian Agricultural Research Institute, New Delhi for getting higher productivity and economics of cauliflower and onion in the system during 2017-18 and 2018-19. Recently released varieties of cauliflower (Pusa Shukti and Pusa Paushja) and onion (Pusa Riddhi and Pusa Madhavi) were evaluated for integrated nutrient management. Both cauliflower varieties were from mid-late maturity group and Pusa Paushja attains maturity in second fortnight of December. Pusa Paushja produces white compact curds, maturity period of 85 days, yields 30-35t ha^{-1} and is recommended for Punjab, U.P., Uttarakhand and Bihar. Pusa Shukti is December-January maturity variety with white compact curd, maturity in 75-80 days and average yield 44 t ha^{-1} (Kalia *et al*. 4). It is recommended for cultivation for National Capital Region (NCR). In case of onion, Pusa Riddhi and Pusa Madhavi were developed mainly for *rabi* season onion varieties. Pusa Madhavi has light red bulbs, flattish round with TSS 11-13%, bulbs mature in 130-145 days, average yield 35 t ha^{-1} and released by Central variety release committee (CVRC) especially for Madhya Pradesh and Maharashtra region. While, Pusa Riddhi was notified during 2016 by SVRC, New Delhi for cultivation in NCT Delhi. This variety has a yield potential of 35t ha^{-1} during *rabi* season. However, it can be grown in *kharif* season also. The bulbs of Pusa Riddhi are compact, flat globe, and dark red in colour. Average equatorial diameter of bulbs ranges from 4.5 – 6.0 cm, polar diameter ranges from 4.8-6.3 cm and single bulb weight ranges from 70 – 80 g. It is pungent and rich in antioxidants (quercetin 107.42 mg/100g) and also suitable for storage and export.

Among nutrient management, five treatments were taken as, conventional practice –recommended dose of fertilizer (RDF), green manuring with RDF, FYM (10t/ha), FYM+ RDF and green manuring + farm yard manure along with biofertilizer (PSB). Organic sources of green manuring and FYM were applied to the first crop in the cauliflower-onion system as per treatment. But the inorganic fertilizers (RDF) were applied to each crop. The experiment was conducted in a fixed plot in factorial randomized block design (RBD) with three replications. The standard analysis of variance (ANOVA) test was performed using SPSS 17.0 statistical software to compare the treatment means for each year separately. Treatment means were compared at the 5% level of significance ($P<0.05$) using least significant difference (LSD). The year variance over years was estimated homogeneous by performing Bartlett's test and results of pooled analysis were analyzed.

RESULTS AND DISCUSSION

Green manuring with *Sesbania* before cauliflower planting resulted in maximum curd yield (34.3 t ha^{-1}) in Pusa Shukti under recommended dose of fertilizer (RDF) initiated nutrient management during 2017-18. Similar trend was recorded during 2018-19 with 35.0 t $ha^{-1}$of curd yield (Table 1). The next best combination was FYM (10 t ha^{-1}) with RDF and with the curd yield of 31.8 and 32.0 t/ha during 2017-18 and 2018-19, respectively. The increase in curd yield under RDF + GM was 21.8% and 25.9% over the conventional practice of using only inorganic fertilizers (RDF). However, the increase under RDF+ FYM and GM+FYM+BF were 13.2 and 15.1 and 4.6 and 8.6 %, respectively over the RDF in Pusa Shukti variety. In case of Pusa Paushja, the response to integrated nutrient management was slightly variable and under GM+RDF though maximum curd yield was recorded but the increase was 21.0 and 18.4% higher over the RDF only (Table 1 and Fig. 1). Whereas, under FYM + RDF, the increase in curd yield was 15.4 and 20 %, respectively over the conventional practice of nutrient management (RDF) during 2017-18 and 2018-19. Further, compared to the use of the only organic source of the nutrients (FYM), the use of inorganic fertilizer (RDF) was found to be superior in terms of yield enhancement of cauliflower in both varieties. However, integration of organic sources in the form of GM+FYM +BF resulted in curd yield improvement over only RDF and over 4-9.3% increase was recorded. Hence, intensive vegetable production needs to be done under integrated nutrient management, essentially by inclusion of *Sesbania* green manuring. *Sesbania*

Table 1: Effect of variety and integrated nutrient management on curd yield, economics, production efficiency and economic efficiency of cauliflower.

Varieties	Treatments	Curd yield (t ha^{-1})		Net return (₹ ha^{-1})		B:C ratio		Production efficiency (kg ha^{-1} day^{-1})		Economic efficiency (₹ ha^{-1} day^{-1})	
		2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
Pusa Shukti	CP (RDF)	28.2	27.8	211.6	208.2	3.02	2.97	376	371	2822	2776
	GM+RDF	34.3	35.0	263.1	269.8	3.29	3.37	457	466	3508	3597
	FYM (10t/ha)	27.5	26.8	205.1	198.0	2.93	2.82	367	357	2734	2641
	FYM+RDF	31.8	32.0	233.7	235.4	2.75	2.76	425	427	3116	3139
	GM+FYM+BF	29.4	30.2	204.6	211.7	2.27	2.35	393	402	2729	2473
Pusa Paushja	CP (RDF)	24.8	25.5	178.9	185.5	2.56	2.64	332	341	2385	2822
	GM+RDF	30.1	30.2	221.4	221.7	2.77	2.77	402	402	2952	2956
	FYM (10t/ha)	24.9	25.3	179.4	182.9	2.56	2.61	333	337	2392	2438
	FYM+RDF	28.7	30.6	202.3	220.8	2.38	2.59	383	408	2697	2944
	GM+FYM+BF	27.2	27.7	182.1	1873.3	2.02	2.08	363	370	2428	2498
CD 5%	Variety	2.56	2.82	20.1	37.8	0.26	0.22	32.6	34.6	272.3	280.3
	INM	2.45	2.62	19.6	37.5	0.25	0.21	30.2	32.5	275.2	281.2

green manuring in addition to the supply of plant nutrients, also provides good amount of Ca in the soil which under salt-affected conditions helps a lot in maintaining optimum soil health, thus ensuring better growth and curd productivity of the cauliflower. Cauliflower nutrient management also affects the nutritive, marketing, and keeping quality of the curd and it demands for efficient management of the Integrated Plant Nutrient Supply System (Thilagam *et al*., 10). Padamwar and Dakore (7) recorded maximum curd weight (1335 g) and curd yield (51.91 t ha^{-1}) due to vermicompost application, followed by the mixture of biofertilizers.

Use of recommended dose of fertilizers (RDF) along with *Sesbania* green manuring during rainy season and planting of onion in cauliflower-onion system resulted in higher onion bulb yield (upto 28 t/ha). In Pusa Riddhi variety of onion, GM+RDF resulted in 12.5 % (3.5 t/ha) and 9.1% (2.5 t/ha) increase in onion bulb yield, whereas FYM+RDF

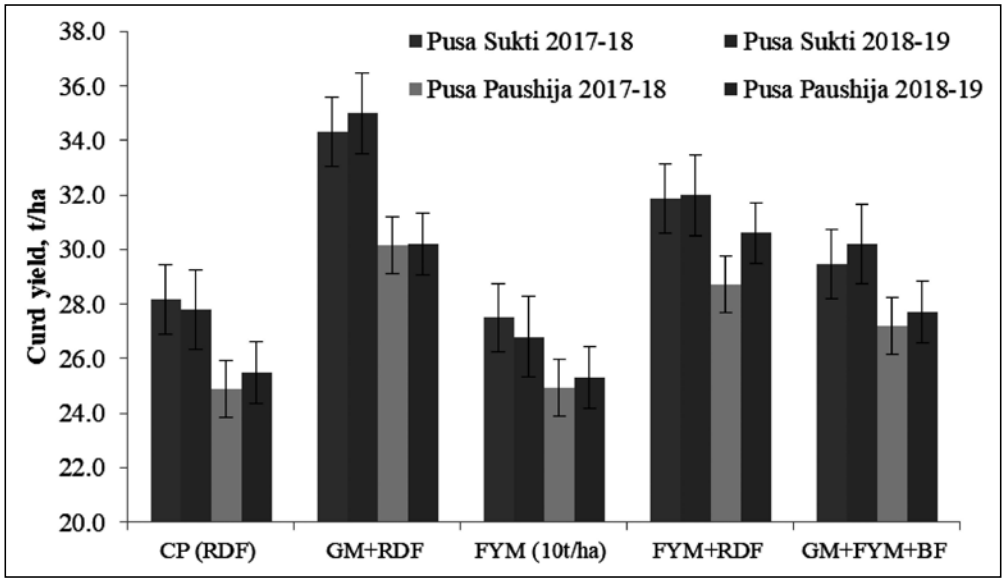

Fig. 1. Effect of different nutrient management practices on curd yield of cauliflower

resulted in 3.6% (additional 1.0 t/ha) and 8 % (2.2 t/ha), respectively during both the years over the conventional practice of RDF. Compared to Pusa Madhavi, higher onion bulb yield enhancement was recorded in the Pusa Riddhi variety. But even in Pusa Madhavi, the response was similar as it was in case of Pusa Riddhi variety (Table 2 and Fig, 2). With RDF omission, a decline of 4.6 and 4.4% was recorded by using only FYM (10 t ha^{-1}) as compared to onion bub yield under RDF during 2017-18 and 2018-19, respectively. Variation in varietal response was also observed for different INM practices during both year. Unlike in the case of cauliflower, the use of different sources of organic nutrients (GM+FYM+BF) resulted in a slight increase in onion bulb yield, and it was 0.5 and 0.4% (almost 0.1 t/ha) over RDF. Hence even a combination of all organic sources was not helpful in getting high onion bulb productivity. Integration of GM, FYM with RDF resulted in higher onion bulb yield during both the year in Pusa Riddhi and Pusa Madhavi varieties.

Integration of organic sources of nutrients with inorganic fertilizers resulted in better economic return from cauliflower. There was net return of ₹51500/- and ₹61600.0 ha^{-1} from Pusa Shukti variety under GM+ RDF compared to only RDF. Whereas, under

Table 2: Effect of variety and integrated nutrient management on yield, economics, production efficiency and economic efficiency of onion.

Varieties	Treatments	Onion bulb yield (t ha^{-1})		Net return (₹ 000'ha^{-1})		B:C ratio		Production efficiency (kg ha^{-1} day^{-1})		Economic efficiency (₹ ha^{-1} day^{-1})	
		2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
Pusa Riddhi	CP (RDF)	28.0	27.6	151.2	150.8	1.23	1.21	1674	1670	1121	1117
	GM+ RDF	31.5	30.1	172.4	171.4	1.34	1.32	1830	1808	1298	1270
	FYM (10t/ha)	25.7	26.6	149.5	151.4	1.30	1.32	1580	1602	1090	1122
	FYM+RDF	29.0	29.8	164.5	165.6	1.22	1.26	1760	1787	1211	1227
	GM+FYM+BF	26.2	27.7	159.7	161.7	1.38	1.4	1601	1655	1205	1198
Pusa Madhavi	CP (RDF)	21.7	22.6	99.8	100.8	0.8	0.81	1401	1423	715	747
	GM+ RDF	25.6	25.1	121.3	121.4	0.92	0.93	1567	1561	928	900
	FYM (10t/ha)	21.4	21.6	101.8	101.5	0.89	0.88	1350	1356	745	752
	FYM+ RDF	25.5	24.8	116.8	115.6	0.9	0.88	1579	1540	845	857
	GM+FYM+BF	23.1	22.7	112.0	111.7	1.0	0.97	1389	1408	810	827
CD 5%	Variety	1.8	1.8	14.2	15.2	0.1	0.1	153	130	110	90
	INM	1.9	1.9	13.9	15.3	0.09	0.1	155	131	105	98

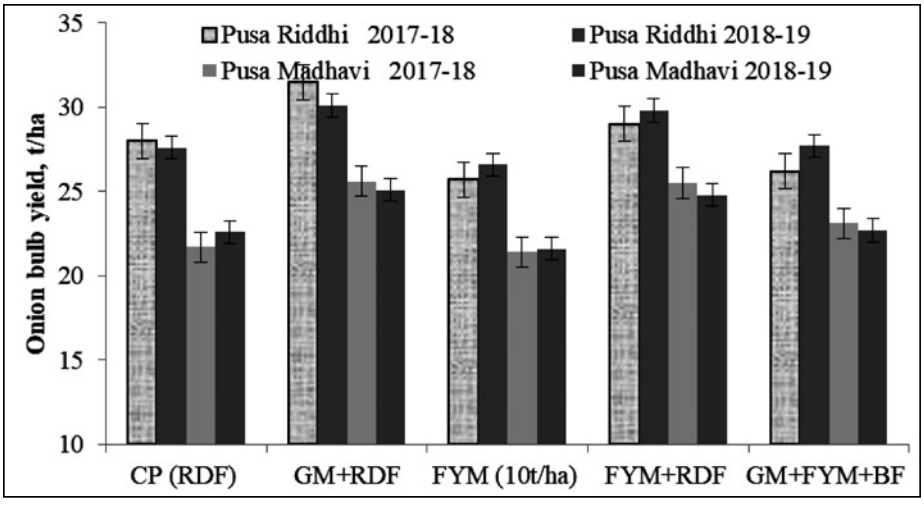

Fig. 2. Effect of different nutrient management practices onion bulb yield of onion

FYM+RDF, a net return of ₹22133 ha^{-1} (10.5%) and ₹27200.0 ha^{-1} (13% increase) over the conventional practice of RDF. Even in Pusa Paushja, 23.8 % (₹42500.0 ha^{-1}) and 19.5% (₹36200.0 ha^{-1}) was recorded under GM+RDF over RDF. The B:C ratio was higher under GM+RDF (3.29 and 3.37) during 2017-18 and 2018-19, respectively. The B:C ratio remained >2.0 in all the nutrient management practices (Table 1). As the cost of cultivation increased with integrated nutrient management, the B:C ratio declined gradually over RDF. Similar was the trend with Pusa Paushja variety in B:C ratio. But, compared to Pusa Paushja, the B:C ratio remained higher in Pusa Shukti variety. This was due to the better response of Pusa Shukti in terms of higher curd productivity. With respect to profitability, > ₹3500/ha/day was recorded under GM+RDF in Pusa Shukti variety, which was only ₹2882 and 2776/ha/day from RDF nutrient management. FYM+ RDF was the next best INM for cauliflower which resulted in the profitability of > ₹3100.0 day^{-1} ha^{-1} in Pusa Shukti. In Pusa Paushja, even with GM+RDF resulted in lower profitability < ₹3000.0 day^{-1}ha^{-1} (Table 1). Production efficiency also remained maximum under GM+RDF in Pusa Shukti variety (457and 469 kg ha^{-1} day^{-1} during 2017-18 and 2018-19, respectively). Use of only FYM was observed with least production efficiency (367 and 357 kg ha^{-1} day^{-1}) in Pusa Shukti variety and this was further lower in Pusa Paushja variety (Table 1). Kalloo and Pandey (5) also reported for use of integrated nutrient sources for higher cauliflower productivity and economic returns. Parmar and Sharma (8) also obtained the highest net income of ₹62,800 ha^{-1} in cauliflower variety Pusa Snowball-1 with the application of 100 per cent recommended doses of NPK and 30 t ha^{-1} FYM due to better nutrition to cauliflower crop.

Onion is one of the high-value crops being used as an ingredient in the preparation of a large number of edible dishes. Because of its higher demand, the market prices of onion remain higher round the years barring a few exceptions. More than ₹1.70 lakh/ha as net return was achieved from GM+RDF with Pusa Riddhi variety. Whereas the least net return of < ₹1.0 lakh ha^{-1} was recorded from GM+FYM+BF. However, FYM+RDF resulted in > 1.6 lakhs ha^{-1} as net return which was also second best in the case of Pusa Riddhi. Compared to Pusa Riddhi variety, a lesser net return was recorded from Pusa Madhavi variety under all INM combinations. In Pusa Madhavi, the maximum net return of ₹1.21 lakh ha^{-1} was recorded under GM+RDF, whereas FYM+RDF resulted in ₹1.16 lakhs ha^{-1}. After the harvest of cauliflower, Pusa Riddhi of onion, in general ensured higher net return. Profitability on per day basis was > 1200 kg ha^{-1} under GM+RDF in Pusa Shukti, whereas in case of Pusa Madhavi the production efficiency was <1000.0 ha^{-1}day^{-1}. Hence on per day profitability and productivity basis the onion variety Pusa Riddhi was found superior over cauliflower variety Pusa Paushja.

The soil health was assessed on the basis of soil organic carbon, available N, P and K. For this purpose, the soil samples were collected before and after the implementation of the cropping system experiment. The data on soil health are presented

Table 3: Effect of variety and INM on soil fertility status before sowing and after harvesting in cauliflower – onion system.

Crop	INM treatments	Before sowing				After harvest			
		OC (%)	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	OC (%)	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
Cauliflower (Pusa Shukti)- Onion (Pusa Riddhi)	CP (RDF)	0.40	125.0	16.2	275.0	0.41	130.1	17.2	282.2
	GM+RDF	0.41	126.3	15.8	289.0	0.43	134.4	17.6	301.0
	FYM (10t/ha)	0.38	125.0	16.5	298.0	0.44	132.7	18.1	310.2
	FYM+RDF	0.38	132.1	16.3	310.0	0.40	138.8	18.2	312.2
	GM+FYM+BF	0.39	132.0	15.6	312.0	0.39	136.2	17.9	316.2
Cauliflower (Pusa Paushja) - Onion (Pusa Madhavi)	CP (RDF)	0.37	126.0	15.2	295.2	0.40	128.0	16.9	300.2
	GM+RDF	0.41	125.0	14.8	306.0	0.41	134.5	17.9	310.2
	FYM (10t/ha)	0.38	124.0	15.1	310.0	0.39	133.2	18.1	360.2
	FYM+RDF	0.35	115.0	14.2	315.0	0.35	125.3	17.9	340.2
	GM+FYM+BF	0.40	120.0	14.4	310.0	0.42	130.0	17.1	321.2
CD 5%	Variety	0.035	12.6	1.56	28.5	0.38	13.2	1.85	30.5
	INM	0.031	12.4	1.60	28.0	0.03	13.1	1.75	29.2

before planting of cauliflower (first crop) and after harvest of onion crop in second season. The soil organic carbon (OC) improved after two years of experimentation under GM+RDF, FYM+RDF and also under GM+FYM+BF (Table 3). The improvement under RDF was not same as it was under organic nutrient sources. The buildup in soil organic carbon under GM and also in FYM was due to addition of more amount of organic matter in the soil through these manures. In due course, the available nutrients were released from the organic manures in the soil through mineralization and more amounts of available nutrients were added in the soil. This was the reason for the improvement of soil fertility under integrated nutrient management practices. Bhardwaj *et al*. (2) reported soil fertility build up and better nutrition to cauliflower under integrated nutrient supply system. It can be concluded from the study that green manuring, along with a recommended dose of fertilizer in the Cauliflower-Onion system resulted not only in higher economic yield but also improvement in soil health in terms of better build up of soil fertility. Also among the varieties, Pusa Shukti of cauliflower and Pusa Riddhi of onion were found best due to their enhanced productivity and better economic returns.

AUTHORS' CONTRIBUTION

Conceptualization of research (SSR, KS); Designing of the experiments (SSR, SD); Contribution of experimental materials (KS, SS); Execution of field/lab experiments and data collection (SSR, SS); Analysis of data and interpretation (SSR, SD); Preparation of the manuscript (SD, SSR).

DECLARATION

The authors declare that there is no conflict of interest.

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