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Effect of integrated nutrient management on yield, soil fertility and economics in *Abelmoschus esculentus* – *Allium cepa* cropping system in semi arid zone of Haryana

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Abstract
A field experiment was conducted during *Kharif* 2014 to *Rabi* 2015 at the Regional Research Station, CCS HAU, Bawal, Haryana to study the effect of integrated nutrient management on yield, soil fertility and economics in *Abelmoschus esculentus* – *Allium cep*a cropping system in semi arid zone of Haryana. Results revealed that highest yield and B: C ratio of okra (37.65 qha^{-1}and 1.19) and onion (173.95 qha^{-1} and 6.19) were recorded with application of 75% RDF + 6t vermi-compost ha^{-1}+ bio-fertilizer. Application of 75% RDF alone significantly reduced the fruit yield of okra by 12.3 and bulb yield of onion by 4.1% over 100% RDF. Application of 75% RDF +15 t FYM ha^{-1} increased the fruit yields okra by 25.6% and onion bulb yield by 8.0%, whereas the application of 75% RDF + 6t vermi-compost ha^{-1} significantly increased the okra fruit yield by 29.6% and onion bulb yield by 11.9% over 75% RDF. Bio-fertilizers application increased the yield of both crops significantly over control and but increase in yield were non-significant over 75% RDF in both the crops. The integrated use of inorganic and organic fertilizer increased the crops yield by 25.9 and 8.4% with 75% RDF+15t FYM ha^{-1}+ bio-fertilizer and by 27.8 and 11.9% with 75% RDF + 6t vermi-compost ha^{-1}+ bio-fertilizer over 75% RDF + bio-fertilizer. The treatment comprising of 75% RDF+ 6t vermi-compost ha^{-1} +bio-fertilizers also maintained the highest available NPK (124.85, 15.85 & 176.05 kg ha^{-1}) after the harvest of okra-onion cropping system. The maximum B:C ratio of 1.19 & 6.19 was recorded under the treatment receiving 75% RDF+6t vermi-compost ha^{-1} + bio-fertilizers in okra and onion crops, respectively.

Keywords: Inorganic fertilizer, FYM, vermi-compost, bio-fertilizer, yield, available nutrients

Introduction
Use of inorganic fertilizers under intensive agriculture has been associated with reduced crop yield, soil acidity and nutrient imbalances. The deteriorating productivity of crops has been found to be associated with deterioration of soil physical and biological qualities besides imbalance in micronutrients (Parmar, 2014) [8]. Integrated nutrient management is optimizing use of inorganic, organic and bio-fertilizers for sustainable agriculture. Organic manure alone and in combination with inorganic fertilizers is found to improve the soil organic C, NPK status and soil microbial growth (Kaur *et al.* 2005 and Kumar *et al.*, 2013) [4, 16]. Ultimately, the INM maintains the productivity of soil improves fertilizer-use efficiency and increases the availability of nutrients. Therefore, the application of plant nutrients through organic sources like vermicompost, FYM and bio-fertilizers remain the alternative choice of growers for maintaining its sustainable production (Guar *et al.*, 1990) [2].

Okra (*Abelmoschus esculentus*) and onion (*Allium sepa*) are important vegetables grown commercially all over the world. In India, they are favorite vegetables which are extensively cultivated throughout the country. Because of their year round availability in the country, there is tremendous scope for export also. They have high nutritive value and play an important role in the human diet (*Emuh et al*., 2006) [1]. Organic nutrition for vegetable is especially important for providing health security to vast vegetarian population in the country. As the vegetables are mostly consumed as fresh or cooked, they should be devoid of residual effect of inorganic chemicals. Since okra and onion are an important commercial crop of South western Haryana and nutrient management for okra–onion cropping system through organic and inorganic source has not been standardized. Therefore, the present study was conducted to find out the most suitable INM treatment to get maximum growth, pod and economic yield of crops the cropping system and as well as good soil health.

Material and methods

The experiment was conducted during 2014-15 at the Regional Research Station, CCS HAU, Bawal, Haryana (latitude 28.1° N, longitude 76.5° E, 266 m amsl).The soil was loamy sand in texture having pH 8.32 (1:2); organic carbon 1.9 g kg^{-1}; cation exchange capacity 3.90 cmol (p+) kg^{-1} and available P and K 10.55 and 169.25 kg ha^{-1}, respectively. The experiment was laid in a randomized block design with three replications on okra (cv. Varsha Uphaar) and onion (cv. H-4). The treatments were T_1–Control;T_2 – 100% RDF; T_3-75% RDF; T_4-75% RDF+ 15t FYM ha^{-1}; T_5-75% RDF + 6t VC ha^{-1}; T_6-75% RDF+bio-fertilizers;T_7-75% RDF+15t FYM ha^{-1}+bio-fertilizers and T_8-75% RDF+6t VC ha^{-1}+biofertilizers. The recommended dose of NP for okra was 100 and 60 kg ha^{-1}, respectively and NPK for onion were 100, 60 and 25 kg ha^{-1}, respectively. The N and P were applied through di-ammonium phosphate and urea; and K through muriate of potash. The crops were raised following recommended practices under irrigated conditions. The row to row and plant to plant distance was 45 and 30 cm in okra and 15 and 10 cm in onion. The okra yield was recorded at each picking and onion yield was recorded at maturity. The soil sample were collected after harvest of each crop and were analyzed for organic carbon, nitrogen (Subbiah and Asija, 1956) [11], phosphorus (Olsen's method, 1954) [7] and potassium estimated by flame photometer.

Results and discussion

Yield of Okra and Onion

Significantly higher yield of okra and onion were recorded under all the treatments over control (Table 1 & Fig 1). The highest yield of okra (37.65 qha-1) and onion (173.95 qha-1) were recorded with 75% RDF + 6t vermi-compost ha^{-1}+bio-fertilizer (T_8). Application of 100% RDF (T_2) increased the okra fruit yield by 68.4% and onion bulb yield by 65.1% over control (T_1) whereas application of 75% RDF (T_3) increased the okra fruit yield by 47.7 per cent and onion yield by 58.3 per cent. The application of 75% RDF significantly decreased the yield of both crops as compare 100% RDF. The yield reduction was 12.3 and 4.1% respectively, in both crops.

The application of organic manures with inorganic fertilizers significantly increased the both crops. Application of 75% RDF +15t FYM ha^{-1} (T_4) increased the fruit yields okra and onion bulb yield by 25.6% and 8.0% whereas the application of 75% RDF + 6t vermi-compost (T_5) was increased the okra fruit yield and onion bulb yield by 29.6 and 11.9% over 75% RDF (T_3), respectively. Bio-fertilizers application with inorganic fertilizer and organic manures (FYM and vermi-compost) also increased the yield of both crops. But the increase was non-significant over 75% RDF (T_3),75% RDF+15t FYM ha^{-1} (T_4) and 75% RDF + 6t vermi-compost ha^{-1} (T_5).Whereas, the increase in okra fruit yield was 25.9 and 27.8% with 75% RDF + 15t FYM ha^{-1} + bio-fertilizer (T_7) and 75% RDF + 6t vermi-compost ha^{-1} + bio-fertilizer (T_8) over 75% RDF + bio-fertilizer (T_6). Similarly, onion yield increased by 8.4 and 11.9% with 75% RDF+15t FYM ha^{-1} +bio-fertilizer (T_7) and 75% RDF + 6t vermi-compost ha^{-1} + bio-fertilizer (T_8) over 75% RDF + bio-fertilizer (T_6), respectively. The beneficial effect of organic manure on yield might be due to additional supply of nutrients as well as improvement in physical and biological properties of the soil (Sharma *et al*, 2009) [9]. It could be attributed to the fact that after decomposition and mineralization, the manure have supplied available nutrients to the plants and have solubilized fixed form of nutrients. The results also demonstrated the superiority of vermi-compost over FYM and bio-fertilizer in okra –onion cropping system. The higher yield of crops with the use of vermi-compost in comparison to FYM may be attributed to higher nutrient content of vermi-compost. Jadav *et al*., (2009) [3] and Sharma *et al.*, (2009) [9] also observed the higher efficacy of vermi-compost over FYM.

Table 1: Effect of organic manure and inorganic fertilizers on yield and economics of Okra – Onion.

Treatment	Okra			Onion			Crop sequences Net returns (Rs.)
	Fruit yield (q ha^{-1})	Net returns (Rs.)	B:C	Bulb yield (q ha^{-1})	Net returns (Rs.)	B:C	
T_1 –Control	19.30	-9675	0.75	98.00	135500	4.31	125875
T_2 –100% RDF	32.50	5121	1.12	161.75	244120	6.19	249241
T_3 -75% RDF	28.50	375	1.01	155.10	233008	6.05	233383
T_4 -75% RDF+ 15t FYM ha^{-1}	35.80	6825	1.15	167.55	252418	6.13	259243
T_5 -75% RDF+6t VC ha^{-1}	36.95	8100	1.17	173.50	261790	6.18	269890
T_6 -75% RDF+ bio-fertilizers	29.45	1750	1.04	155.45	232938	6.05	234688
T_7-75%RDF+15tFYM ha^{-1} + bio-fertilizers	37.10	8225	1.18	168.55	254118	6.15	262343
T_8-75% RDF+ 6t VC ha^{-1}+bio-fertilizers	37.65	9057	1.19	173.95	262500	6.19	271550
CD (P=0.05)	2.10	-	-	5.68	-	-	-

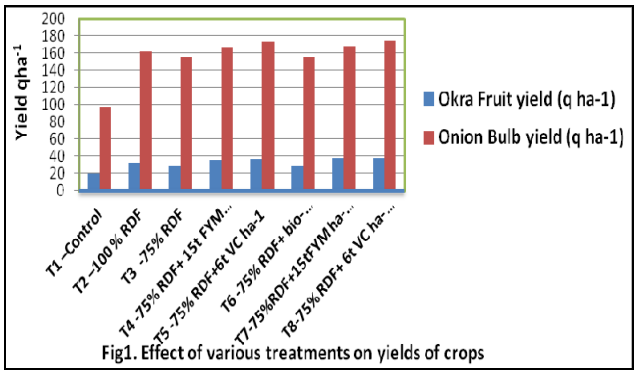

Fig1. Effect of various treatments on yields of crops

Soil Nutrient Build Up

Organic carbon

Soil organic carbon increased significantly with inorganic fertilizers and organic manures over control (Table 2). Application of 100% RDF (T_2) alone increased the organic carbon content by 5.3% whereas application of 75% RDF (T_3) was not found to have any effect on soil organic carbon content. However application of 75% RDF with organic manures significantly increased the soil organic content. The increase in soil carbon content was 10.5% with 75% RDF + FYM (T_4) and 75% RDF + vermi-compost (T_5) over with 75% RDF alone (T_3) and control (T_1). The application of Bio-fertilizer alone and in combination with inorganic and organic manures had no effect on soil organic carbon content. The increase in organic carbon content may be attributed to

addition of organic materials and better root growth. These observations are in agreement with the findings of Sharma *et al*. (2009) [9].

Available nitrogen

Significant higher available N in soil was recorded with application of inorganic and organic manures over control. The treatment comprising of 75% RDF+ 6t vermi-compost + bio-fertilizers (T_8) maintained the highest available N content (124.85 kg ha^{-1}) after the harvest of okra-onion cropping cropping system. The application of 100% RDF (T_2) and 75% RDF (T_3) significantly increased the available N content over control by 15.9 and 4.2% respectively. It differed significantly more with combined application of inorganic and organic manures. Application of FYM @ 15t ha^{-1} and vermi-compost @ 6t ha^{-1} with 75% RDF increased the available N content of soil by 14.1 and 15.7%, respectively. However, treatment having FYM and vermi-compost with 75% RDF did not differ significantly among each other. Bio-fertilizer with 75% RDF (T_5) was not found to have significant effect on available N content over 75% RDF (T_3). Integrated application of inorganic fertilizers + organic manure + bio-fertilizers significantly increased the available nitrogen over control (T_1), 75% RDF (T_3) and 100% RDF (T_2). The soil available N content with 75% RDF+ 15 t FYM + bio-fertilizers (T_8) and 75% RDF+ 6t vermi-compost + bio-fertilizers (T_8) (T_5) was statistically at par each other as well as at par with 75% RDF + 15t FYM (T_4) and75% RDF+ 6t vermi-compost (T_5). The increase in available nitrogen with application of FYM and vermi-compost might be attributed to the direct addition of nitrogen through these sources to the available pool of the soil. Sharma *et al*., (2009) [9] and Parmar (2014) [8] also observed enhancement in available N content with the use of organic manures.

Available phosphorus

Significant higher available phosphorus in soil was recorded with application of inorganic and organic manures over control. The treatment comprising of 75% RDF+ 6t vermi-compost +bio-fertilizers (T_8) maintained the highest available phosphorus (15.85 kg ha^{-1}) after the harvest of okra-onion cropping system. The application of 100% RDF and 75% RDF significantly increase the available P content over control by 29.8 and 21.9% respectively. It differed significantly more with combined application of inorganic and organic manures. Application of FYM @ 15t ha^{-1} and vermi-compost @ 6t ha^{-1} with 75% RDF increased the available P content of soil by 10.8 and 16.4%, respectively over 75% RDF. Combined application of FYM and vermi-compost with 75% RDF did not differed significantly among each other. Bio-fertilizer with 75% RDF (T_5) was not found to have significant effect on available P content over 75% RDF (T_3). Integrated application of inorganic fertilizers + organic manure + bio-fertilizers significantly increased the available phosphorus over control (T_1), 75% RDF (T_3) and 100% RDF (T_2). The soil available P content with 75% RDF+ 15 t FYM + bio-fertilizers (T_8) and 75% RDF+ 6t vermi-compost + bio-fertilizers (T_8) was statistically at par each other as well as at par with 75% RDF + 15t FYM (T_4) and 75% RDF+ 6t vermi-compost (T_5). The increase in available phosphorus content with inorganic and organic sources might be attributed to the direct addition of phosphorus through these sources as well solubilzation of native P through release of many organic acids in the soil. Similar increase in available P content with integrated use of inorganic fertilizer and organic manures have also been observed by Sharma *et al*., (2009) [9] and Kumar *et al*. (2013) [6].

Available potassium

The available potassium differed with two levels of inorganic fertilizer in combination with organics (Table 2). The treatment comprising of 75% RDF+ 6t vermi-compost +bio-fertilizers (T_8) maintained the highest available potassium (176.05 kg ha^{-1}) after the harvest of okra-onion cropping system. The application of 100% RDF (T_2), 75% RDF (T_3), 75% RDF+ 15t FYM (T_4) and75% RDF +bio-fertilizers (T_6) increased soil available K content over control but the increase was not significant. However, integration of vermi-compost @ 6t ha^{-1} with 75% RDF increased the available K content of soil significantly over control (T_1), 75% RDF (T_3) and 100% RDF (T_2) and was at par with 75% RDF+ 15t FYM (T_4). Both the treatments (T_4 &T_5) also did not differ significantly among each other. Bio-fertilizer with 75% RDF (T_5) was not found to have significant effect on available K content over 75% RDF (T_3). Integrated application of inorganic fertilizers + organic manure + bio-fertilizers significantly increased the available potassium content over control (T_1), 75% RDF (T_3) and 100% RDF (T_2). However, treatments 75% RDF + 15t FYM (T_4), 75% RDF + 6t vermi-compost (T_5), 75% RDF+ 15t FYM + bio-fertilizers (T_7) and 75% RDF+ 6t vermi-compost (T_8) increased available K content and were found to be at par with each other. The addition of vermi-compost was found to have more significant effect on available K content than FYM. The beneficial effect of FYM and vermi-compost might be attributed to the direct addition of potassium through these sources. Sharma *et al.* (2009) [9] and Parmar (2014) [8] also recorded the higher available K content with the conjoint use of fertilizers and organics manures.

Table 2: Effect of organic manure and inorganic fertilizers on soil properties after harvest of Okra – Onion.

Treatments	Organic carbon (g kg^{-1})	Available Nutrients (kg ha^{-1})		
		N	P	K
T_1 –Control	1.9	102.25	10.25	168.05
T_2 –100% RDF	2.0	118.50	13.30	169.20
T_3 -75% RDF	1.9	106.50	12.50	168.35
T_4 -75% RDF+ 15t FYMha-1	2.1	121.50	13.85	172.15
T_5 -75% RDF+6t VCha-1	2.1	123.20	14.55	173.10
T_6 -75% RDF+ Bio-fertilizers	1.9	108.75	12.90	169.60
T_7-75%RDF+15tFYMha-1+Biofertilizers	2.1	121.90	15.10	172.45
T_8-75% RDF+ 6t VCha-1+Biofertilizers	2.1	124.85	15.85	174.05
CD (P=0.05)	0.01	4.22	1.20	4.00

Economics

The data in Table 1 revealed that higher monetary returns of crop sequence (okra-onion) was obtained with 75% RDF+ 6t vc ha^{-1}+bio-fertilizers. This treatments gave higher fruit yields of okra and onion sequence with net returns of Rs. 271550 as compared to Rs.269890 under 75%RDF+6 t vermi-compost ha^{-1} and Rs. 262343 under 75% RDF + 75% RDF+ bio-fertilizers. The higher value of net returns recorded under treatments receiving vermi-compost and FYM along with fertilizers is attributed to a distinctly higher fruit yield giving the highest gross returns. Among various treatments tested, the maximum B:C ratio of 1.19 and 6.19 was recorded under the treatment receiving 75% RDF+6t vermi-compost ha^{-1} + bio-fertilizers (T_8) in okra and onion crops, respectively. The

effect of FYM on B:C ratio was found to be lower than vermi-compost which may be attributed to the higher unit cost of nitrogen (4 times) when supplied through FYM as compared to chemical fertilizer. Similar findings have been reported by Kaushik *et al.* (2012) [5] and Singh *et al.* (2012) [10].

It may be concluded from the results of the study that production potential of okra –onion cropping sequence can be improved with integrated use of fertilizer with organic manures. Also, soil fertility and monetary returns can be positively enhanced by integrated use of manures and fertilizers.

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