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Assessment of fertilizer-use efficiency under enhanced crop intensity of vegetables due to intercropping using ^{15}N and ^{32}P labeled fertilizers*

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Fertilizing multi-cropping with high analysis fertilizers is an essential aspect of intensive agriculture to maximize crop production per unit area and time (Prabhakar 1993). Vegetable crops are still in the active growth phase at harvest with high concentration of nutrients in soil solution and therefore substantial fertilizer residues result (Scaife and Bar-Yosef 1995). This has significant influence on the fertilizer-use efficiency when the cropping intensity is enhanced. An attempt was therefore made to evaluate the nutrient-use efficiency of the crop combination of: capsicum (*Capsicum annuum* L., main crop), onion (*Allium cepa* L., intercrop) – watermelon (*Citrullus lanatus* Thunb., main crop), radish (*Raphanus sativus* L., intercrop) – okra (*Abelmoschus esculentus* L., main crop), French-bean (*Phaseolus esculentus* L., intercrop) raised successively during September 2004–December 2005 using ^{15}N and ^{32}P labeled fertilizers.

A field experiment was undertaken in cement-asbestos vats of 1 m × 1.8 m embedded up to a depth of 50 cm in the soil. The crop was raised on a sandy loam (Typic Haplustalf) soil having a *p*H of 5.9, organic carbon of 0.3%, cation exchange capacity of 8.7 cmol (p^+)/kg, available N of 246 kg/ha and Bray-I P of P of 15.5 kg/ha. The fertilizer doses applied were: 200:100:100 NPK kg/ha for 'Indra' capsicum and 'Arka Lalima' onion, 100:80:100 for 'NS–295 F_1' water melon, 100 : 50 : 50 for 'Arka Nishant' radish, 120 : 80 : 40 for 'US Agriseeds 7109' okra, and 80:100:40 for 'Arka Komal' French bean. The treatments consisted of (i) main (sole) crops to receive their own full dose of fertilizers; (ii) intercrops (sole) to receive their own full dose; and (iii) in the crop combination of sole and intercrops raised simultaneously, only the main crops to receive 150% their own dose and none for the inter-crops. The treatments were replicated 4 times in a completely randomized block design. The main (sole) crop and intercrop in each season were planted simultaneously in the same plot. Nitrogen was applied as ^{15}N-enriched urea having 1.0 atom% excess and phosphorus was applied as ^{32}P-labelled superphosphate of specific activity of 0.2 mCi/g of P. The economic produce (fruit/pod, root or bulb) was harvested appropriately and bulked to estimate dry weight and nutrient content. At the time of final harvest the plants were cut above ground and separated into leaf and stem. The plant samples were digested in 9.4 nitric:perchloric acid mixture and total P in the digest estimated using yellow vanadomolybdate colorimetric method. Nitrogen in the plant samples was estimated using Kjeldahl method. For determining ^{15}N abundance the distillate was impregnated on discs of Whatman filter paper and dried. Abundance of ^{15}N in the discs was estimated using ratio mass spectrometer and the activity of ^{32}P using liquid scintillation counter. The assay of ^{15}N abundance was carried out after 150 days of sampling when the activity of ^{32}P had declined to background level. Nutrient-use efficiency was calculated as the ratio of the uptake of the labelled nutrient by the crop and the labelled fertilizer nutrient applied to the crop expressed as the percentage. For comparing the yield of different crops, the yield was expressed as capsicum-equivalent in capsicum, onion combination, as watermelon-equivalent in watermelon, radish combination, and as okra-equivalent in okra, Frenchbean crop combination based on prevailing wholesale market prices (capsicum, Rs 10/kg; onion, 4.50; watermelon 3.00; radish, 2.00; okra, 9.90; French bean, 10.00 as per National Horticultural Board, New Delhi for Bangalore market).

The crop combination of watermelon and radish showed yield similar to that of watermelon, the main crop (Table 1). In the other crop combinations of capsicum and onion as well as okra and Frenchbean, the yield was significantly

*Short note

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Table 1 N and P fertilizer utilization and yield under different solo crops and their combinations

Treatment	Capsicum*, onion**	Watermelon*, Radish**	Okra*, Frenchbean**
	Yield# (kg/1.8 m²)		
Sole crop 1*	6.3	15.5	5.6
Sole crop 2**	2.7	8.9	2.4
Crop combination$	4.4	15.6	5.5
SEm (±)	0.10	0.25	0.14
CD (*P*=0.05)	0.35	0.88	0.48
	Fertilizer N utilization (%)		
Sole crop 1*	10.85	23.70	22.76
Sole crop 2**	25.25	37.16	23.10
Crop combination$	6.60	19.12	6.44
SEm (±)	0.590	0.843	0.821
CD (*P*=0.05)	2.042	2.916	2.839
	Fertilizer P utilization (%)		
Sole crop 1*	11.90	4.89	8.24
Sole crop 2**	7.09	10.43	10.14
Crop combination$	6.18	6.13	9.31
SEm (±)	0.146	0.128	0.229
CD (*P*=0.05)	0.504	0.442	0.792

*Main crop, ** intercrop, #Capsicum-equivalent in capsicum, onion; watermelon-equivalent in watermelon, radish; and okra-equivalent in okra, Frenchbean crop combinations, $crop combination of respective main and intercrop.

lower than that of the respective sole crop of main crop but higher than that of the sole crop of the intercrop.

Nitrogen-use efficiency of the sole crops differed widely (10.85–37.16%) and significantly except between okra and Frenchbean (22.76–23.10%). However, N-use efficiency of all the 3 crop combinations was significantly reduced compared to either of sole crops of the combinations. Generally, the enhanced cropping intensity showed smaller recovery of N than sole crops. Similar results were obtained by Patra *et al*. (1960) in maize (*Zea mays* L.) +_ cowpea [*Vigna ungiculata* (L.) Walp.] intercropping. This is also partly attributed to relatively lower yield under crop combination as also the increased denominator (150% of the recommended dose applied to main crop of the crop combination). This appears to be a procedural difficulty and there does not appear to be an alternative to be more realistic. Due to competition between the main and intercrop in the combination, the yield and uptake of fertilizer N of both the crops were adversely affected. The findings showed that the strategy of crop combination where the main crop receives an enhanced dose to sustain the crop combination reduced the overall N-use efficiency and may lead to a substantially higher residual fertilizer nutrient. There is a need to rethink on the fertilizer application practices of crop-combinations as also to refine the isotope technique to evaluate nutrient/fertilizer-use efficiency in crop-combination experiments.

Phosphorus-use efficiency of different crops in the crop-combinations varied significantly (4.88–11.90%). In respect of capsicum (onion) crop combination, the P-use efficiency (6.18%) was similar to that of onion (sole crop 2; 7.19%) but significantly lower than that of capsicum (sole crop 1; 11.90). The P-use efficiency of all the crop combinations was intermediate between that of the respective sole crop 1 and sole crop 2 in respect of watermelon, radish as well as okra, Frenchbean crop combinations. The reduction of fertilizer-use efficiency of N under different crop combinations was appreciably higher than that of P fertilizer under crop combinations which may be related to the differential mobility of N and P in the soil.

SUMMARY

Nitrogen-use efficiency of all the crop combinations: capsicum (main crop), onion (intercrop); watermelon (main crop), radish (intercrop); okra (main crop), Frenchbean (intercrop) was drastically reduced from 10.85–37.16% to 6.44–19.12% compared to the either of the sole (main) crops. In the case of P also similar trend was seen but the utilization of P by crop combination was intermediate (6.18–9.31%) between those of the respective sole crops (in the rate of 4.89% for watermelon and 11.90% for capsicum). The reduction of fertilizer-use efficiency of N under different crop-combinations was appreciably higher than that of P fertilizer under crop combinations.

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