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Short communication

Yield and nutrient dynamics under fruit-based diversified cropping models for arid region of Rajasthan

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ABSTRACT

The plant height, plant girth and yield of *aonla* varied considerably in different cropping model systems. Highest yield of *aonla* was recorded in *aonla-khejri* (46.2 kg/ plant) followed by *aonla-ber* (44.7 kg/ plant), while the lowest *aonla* yield was recorded in *aonla*-drumstick (40.6 kg/ plant). Maximum organic carbon (0.25%), electrical conductivity (2.00 dS/m) and pH (8.28) was recorded under *aonla-khejri*-cluster bean-*ajowain* cropping model followed by *aonla-ber*-cluster bean-fennel. Similarly, the maximum available nitrogen (210.3 kg N/ha), potassium (401.26 kg K/ha), micro-nutrients (Zn 5.11; Cu 0.59; Fe 12.21; Mn 12.91 ppm) and microbial population (bacteria 271 CFU x10^6; fungal 221 CFU x10^3; actinomycetes 116 CFU x10^3) were under *aonla-khejri*-cluster bean-*ajowain* cropping system. It was concluded that for arid conditions of Rajasthan, *aonla-khejri* and *aonla-ber* combinations were superior compared to other cropping systems.

Key words: Yield, nutrient dynamics, fruit, diversified cropping, arid region, Rajasthan.

Land, which is the most precious heritage and the physical base of biomass production of life supporting systems, is finite (Yadav *et al*., 8). Sustainable utilization of land is a must in view of rapidly depleting natural resources. Introduction of fruit tree based production system into existing cropping systems in regions of adverse climatic conditions could be seen essentially as a strategy to reduce the risk in net returns of crops due to yield uncertainty. In addition, inclusion of fruit trees in a cropping system encourages soil health and reduces erosion. Fruit based cropping system is recommended from the point of view of increasing and sustaining the soil fertility. The fruit-based cropping system is highly adaptable and applicable to a wide area and range of physical and social conditions, worldwide (Sharma *et al.*, 7).

In the present investigation, evaluation of fruit based diversified cropping models integrating complementary crop components as ground storey agricultural, spice and fodder crops with a view to develop a cropping system, which have potential advantages in production, stability, resilience to perturbation and ecological sustainability. After completion of nine years cycles of different cropping models, *viz*., *aonla-ber*-cluster bean-fennel (M-1), *aonla-bael*-cluster bean-coriander (M-2), *aonla-khejri*-cluster bean-*ajowain* (M-3), *aonla*-drumstick - cluster bean-dill (M-4), *aonla-karonda*-grass (*L. sindicus*) (M-5) and *aonla* sole were assessed at ICAR-CIAH, Bikaner. *Aonla* was chosen as the base crop while *ber, bael*, *khejri,* drumstick and *karonda* as component crops. After completion of three cycles, beginning from seventh year of plantation, composite surface soil samples (0-30 cm) were taken from each plot, air-dried and passed through 2 mm sieve. Soil pH was determined in soil water suspension (1:2). Composite soil samples for organic carbon, available NPK, DTPA extractable micro-nutrients (Zn, Fe, Mn and Cu) were analyzed as per the standard procedures. Microbial population was estimated by serial dilution techniques. Water holding capacity was estimated by pressure plate and pressure membrane apparatus.

Different models of fruit-based cropping system significantly varied in plant height, trunk girth, and yield (Table 1). Maximum increase in plant height (4.81 cm) was observed under sole *aonla* followed by *aonla-ber* (4.14 cm), *aonla-khejri* (3.87 cm), *aonla-bael* (3.76 cm), *aonla*-drumstick (3.45 cm) and *aonla-karonda* (3.15 cm). Plant height was 14, 20, 22, 28 and 34% were lower *in aonla-ber*, *aonla-khejri*, *aonla-bael*, *aonla*-drumstick and *aonla-karonda*, respectively as compared to sole *aonla* crop. However, trunk girth of *aonla* in *aonla-ber* (48 cm), *aonla-khejri* (43 cm), *aonla-bael* (42 cm), *aonla*-drumstick (37 cm) and *aonla-karonda* (40 cm) system was 37, 23, 20, 6 and 14% higher than sole *aonla* plantation.

The average yield of *aonla* varied considerably in different cropping model with highest being recorded in *aonla-khejri* (46.2 kg/ plant) followed by *aonla-ber* (44.7 kg/ plant), *aonla-bael* (43.4 kg/ plant) and

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Table 1. Plant height, plant girth, yield under fruit-based diversified cropping models.

Cropping model	Plant height (m)	Plant girth (cm)	Yield (kg/ plant)
Aonla	4.81	35	33.5
Aonla + *ber*	4.14	48	44.7
Aonla + *bael*	3.76	43	43.4
Aonla + *khejri*	3.87	42	46.2
Aonla + drumstick	3.45	37	40.6
Aonla + *karonda*	3.15	40	42.5
Min.	3.15	35	33.5
Max.	4.81	48	46.2
Av.	3.86	41	41.8
CD at 5%	0.32	5.3	3.4

aonla-*karonda* (42.5 kg/ plant), while the lowest was recorded in *aonla*-drumstick (40.6 kg/ plant). The higher yield in *aonla* involving *ber* and *khejri* could be due to synergistic crop interaction. The average yield of *bael* was recorded to be 20-25 kg/tree, while a single fruit weighed around 1.36 kg with maximum and minimum fruit weights recorded to be 2.7 kg and 0.7 kg, respectively. The average yield of *karonda* was recorded up to 13.4 kg/ plant planted in between *aonla* plants. Likewise, the yield of *ber* cv. Seb was recorded 50.6 kg/ plant in model M-1. Sharma *et al.* (7) reported that multiple cropping system significantly improved growth attributes of pomegranate compared to monoculture cropping practice. Similarly, the improved growth of *aonla* under multiple cropping systems is likely to manifest itself in realization of higher yield as observed in this study.

Enhancing the long-term sustainability in productivity of crops and cropping systems is directly related to maintenance of an adequate level of soil organic matter. The benefits of maintaining desired levels of organic carbon in low input agro-ecosystem are many like retention and storage of nutrient, increase in buffering capacity of soil, improvement in moisture retention and increased cation exchange capacity. Other benefits are activation of inherent microorganisms in rhizosphere (Manna *et al.*, *5*). These aforementioned attributes consequently leads towards improved soil health and; thereby, bring sustainability in production system. Fruit trees contribute increase in organic carbon content in the soil due to decomposition of fallen leaves from them.

In this study, the maximum value of organic carbon (OC), electrical conductivity (EC) and pH was under *aonla*-*khejri*-cluster bean-*ajowain* cropping model (0.25%, 2.00 dS/m and 8.28, respectively) followed by *aonla*-*ber*-cluster bean-fennel (0.23%, 1.61 dS/m and 8.26, respectively) (Table 2). The inclusion of legumes and cover crops linearly increase organic matter (OM) in soils (Kong *et al.*, 4). Beer *et al.* (2) noted OM in the 0-45 cm layer increased over 10 years by 42 and 16 Mg ha^{-1} in the cacao–*Erythrina poeppigiana* and in the cacao-*Cordia alliadora*, respectively. Similarly, the maximum available nitrogen (210.0 kg/ha), potassium (401.26 kg/ha) and micronutrients (Zn, Cu, Fe and Mn; 5.11, 0.59, 12.21, 12.91 ppm, respectively) were under *aonla*-*khejri*-cluster bean-*ajowain* cropping model followed by *aonla*-*ber*-cluster bean-fennel (200.20 kg N/ha, 359.59 kg K/ha and Zn 4.01; Cu 0.45; Fe 12.01; Mn 12.76, respectively) (Table 2). Saran *et al.* (6) noted that inclusion of mango and litchi in

Table 2. Soil properties and micro-nutrient contents under different fruit-based cropping models.

Cropping model	OC (%)	EC (dS/m)	pH	N (kg/ha)	K (kg/ha)	Micronutrient (ppm)			
						Zn	Cu	Fe	Mn
Initial status	0.02	1.00	7.81	105.30	267.56	0.41	0.25	5.75	6.00
Aonla	0.08	1.42	7.25	145.25	290.23	0.98	0.31	8.65	8.75
Aonla + *ber*	0.23	1.61	8.26	200.20	359.59	4.01	0.45	12.01	12.76
Aonla + *bael*	0.24	1.94	8.27	154.00	289.82	2.18	0.32	7.44	10.03
Aonla + *khejri*	0.25	2.00	8.28	210.30	401.26	5.11	0.59	12.21	12.91
Aonla + drumstick	0.09	1.47	8.22	169.40	332.76	1.09	0.35	8.66	10.68
Aonla + *karonda*	0.13	1.74	8.22	154.00	327.39	1.83	0.39	10.16	9.73
Min.	0.02	1.00	7.25	105.30	267.56	0.41	0.25	5.75	6.00
Max.	0.25	2.00	8.28	210.30	401.26	5.11	0.59	12.21	12.91
Av.	0.15	1.60	8.04	162.64	324.09	2.23	0.38	9.27	10.12
CD at 5%	0.05	0.32	0.26	32.56	44.75	0.16	0.04	1.26	1.75

Table 3. Water holding capacity and microbial population in soil under-fruit based diversified cropping models.

Cropping model	Water holding capacity (%) at 1/3 atm.	Water holding capacity (%) at 6 atm.	Bacterial population (cfu x10^6/g dry soil)	Fungal population (cfu x10^3/g dry soil)	Actinomycetes population (cfu x10^3/g dry soil)
Aonla	1.48	0.52	145	86	73
Aonla + *ber*	2.28	1.1	205	164	105
Aonla + *bael*	2.14	0.99	180	91	79
Aonla + *khejri*	2.07	1.03	271	221	116
Aonla + drumstick	1.84	0.26	201	116	88
Aonla + *karonda*	1.76	0.61	160	97	81
Min.	1.48	0.26	145	86	73
Max.	2.28	1.1	271	221	116
Av.	1.93	0.75	194	129	90
CD at 5%	0.13	0.32	19	14	11

turmeric plantation was found to have cost positive impact on the base crop.

Soil management practices that increase the soil water holding capacity by improving the OM content in soil resulting in better ability of roots to extract more water from the soil profile has positive impact on water use efficiency (WUE), assuming these changes result in a concurrent increase in crop growth and yield. In case of annual crops, 74% of roots do not go beyond 50 cm soil depth, whereas in case of perennial crops, top 50 cm almost devoid of feeder roots (Awasthi and Saroj, 1). The spatially differential root distribution of different component crops in the system helps in higher nutrient and WUE of the multitier system as a whole as a result of presence of feeder roots of the component crops at different depths. In the present investigation, maximum water holding capacity at 1/3 and 6 atm was observed under *aonla* + *ber* (2.28 and 1.10%) followed by *aonla* + *khejri* (2.07 and 1.03%), *aonla* + *bael* (2.14 and 0.99%), *aonla* + *karonda* (1.76 and 0.61%) and *aonla* + drumstick (1.84 and 0.56%) (Table 3). Evanlyo *et al*. (3) reported that water holding capacity of any soil is directly influenced by its organic carbon contents, which is also evident in our study wherein, *aonla* + *khejri* showed maximum accumulation of soil organic carbon as well as water holding capacity. These results are in conformity with the reports of Sharma *et al.* (7).

Fruit based diversified cropping models provides ecological niches for microorganisms and encourages microbial diversity. Microbial count in the rhizosphere of different diversified cropping systems clearly indicates higher bacterial, fungal and actinimycetes population (271 cfu x10^6, 221 cfu x10^3 and 116 cfu x10^3, respectively) in *aonla* + *khejri* followed by *aonla* + *ber* (205 cfu x10^6, 164 cfu x10^3 and 105 cfu x10^3), *aonla* + *bael*, *aonla* + *karonda* and *aonla* + drumstick (Table 3). The rhizo-deposition of nutrients by plant roots supports increased microbial growth. Plant species and seasonal changes affect the indigenous bacterial soil communities and function of fungal communities.

It can be concluded that fruit based diversified cropping system resulted in the increase of the essential relevant elements in soil, which in turn have improved plant growth attributes, physical and physio-chemical attributes of the soil. *Aonla* + *khejri* followed by *aonla* + *ber* systems were found superior than other cropping systems for arid regions of Rajasthan.

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