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Vegetable based intercropping system in pomegranate under hot arid region

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Abstract

Field experiments were conducted at farmer's field in Charanwala branch of IGNP stage-II *i*n Bikaner district of Rajasthan during rabi and kharif seasons of 2015-16 and 2016-17, respectively to study the productivity and economic returns of pomegranate based intercropping systems in one and half year old pre-bearing orchard of pomegranate (*Punica granatum* var. Bhagwa). There were five treatment combinations *i.e.* (i) Pomegranate + onion (*Allium cepa*)- Indian squash (*Citrullus lanatus* var. *fistulosus*), (ii) Pomegranate + radish (*Raphanus sativus)*- cowpea (*Vigna unguiculata*), (iii) Sole onion- Indian squash, (iv) Sole radish- cowpea and (v) Sole pomegranate. Intercropping has positive effect on height, girth and canopy spread of pomegranate tree over its sole plantation. The annual system productivity in terms of onion equivalent yield (OEY) was maximum in sole onion-Indian squash system which was at par with inter-copping system of pomegranate + onion-Indian squash. Water productivity can be improved to 2.87 and 6.71 kg m^{-3} in terms of economic yield (WP_{EY}) and 130.5 and 378.6 Rs $ha^{-1} mm^{-1}$ in terms of gross return (WP_{GR}) with intercropping system of pomegranate +radish- cowpea and pomegranate + onion- Indian squash, respectively as compared to sole pomegranate plantations. An additional income of Rs. 2.36 lakhs/ha/year can be obtained with intercropping system of pomegranate + onion- Indian squash and 0.49 lakhs/ha/year with pomegranate + radish-cowpea intercropping system over sole plantations of pomegranate.

Key words: Economics, pomegranate, intercropping system, water productivity, yield

Introduction

Thar desert of Rajasthan occupies about 62% of the total arid region of India. The region is characterised by extremes of climatic conditions with low rainfall and high temperature. The greater proportion of agriculture in this region is resource constrained, subsistence and practiced under rainfed conditions. Yield losses associated with water stress and soil erosion are common in this zone (Soni *et al.,* 2013; Soni *et al.*, 2017 and Santra *et al.,* 2017). With the advancement of irrigation facility through IGNP, growing of suitable horticultural crops *viz*. pomegranate, kinnow, karonda, acid lime, mosambi *etc*. are now becoming popular and their area is increasing day by day.

Pomegranate is an important crop of arid region. The farmers grow pomegranate as sole crop and the interspaces are left unused. Suitable crop combinations in the inter-space of orchard during initial years can generate extra income (Ghosh and Pal, 2010), kinnow (Bhatnagar *et al.*, 2007) and ber (Birbal *et al.*, 2013), enhance productivity, ameliorate and improve ecological situation in a sustainable manner (Awasthi *et al.*, 2009). Though intercropping of fruit trees with suitable vegetables seems remunerative, yet meager scientific information is available regarding production, water productivity and economics of vegetable based intercropping systems with pomegranate in arid region of Rajasthan. Hence, the present experiment was conducted to assess the yield, water productivity and economic performance of vegetable based intercropping system during establishment phase of pomegranate in light textured soil of arid region of western Rajasthan.

Materials and Methods

Field experiment was carried out at farmer's field located at RD-33 of Charanwala branch of IGNP stage-II (72° 25' E longitude and 27° 51' N latitude) during *rabi* and *kharif* season of 2015-16 and 2016-17, respectively *i*n Bikaner district of Rajasthan. The region is characterised by arid climatic conditions with undulating topography and low to medium height sand dunes. The soil of the experimental site was sandy in texture with low soil organic carbon, alkaline in reaction and non-saline in nature. The bulk density (BD), cation exchange capacity (CEC), pH, permanent wilting point (PWP) and field capacity (FC) ranged between 1.52 to 1.57 Mg/m^3, 4.5 to 5.6 cmol (p^+) /kg, 7.9 to 8.3, 0.04 to 0.06 m^3/m^3 and 0.11 to 0.14 m^3/m^3, respectively depending upon soil depth. The CEC, pH, PWP, FC and soil water content increased with increase in soil depth, whereas BD, soil organic carbon, available N and EC decreased with increase in soil depth.

The experiment was conducted in one and half year old pre-bearing orchard of pomegranate (variety Bhagwa) spaced at

4 m x 3 m apart. In the inter-space of pomegranate, intercrops were sown 0.5 m away from pomegranate tree in either side of the trunk in a plot size of 3 m x 12 m in randomized block design with five treatments and four replications. The treatment combinations were as follows: T_1: Pomegranate + onion (*Allium cepa*) - Indian squash (*Citrullus lanatus* var. *fistulosus*),T_2: Pomegranate + radish (*Raphanus sativus)*- cowpea (*Vigna unguiculata*), T_3: Sole onion- Indian squash, T_4: Sole radish- cowpea and T_5: Sole pomegranate. The recommended packages of practices were followed for pomegranate and intercrops. Pomegranate plants were maintained with drip irrigation during dry periods (4 litre/tree/day for sole tree and 4 litre/tree at every 3rd day for trees in intercropping system). Intercrops were irrigated with mini-sprinkler irrigation. The total amount of irrigation water applied in the system (irrigation + rainfall) has been shown in Fig. 2. Plant protection measures and intercultural operations were done as and when required for both the components. Physico-chemical properties of the soil were analyzed by standard procedures (Jackson, 1973). The growth and yield data were recorded and system productivity was calculated in terms of onion equivalent yields (OEY). The OEY for different intercrops (both *kharif* and *rabi* season crops including fruit crop) was calculated based on selling price of the produce and yield of intercrops using Eq-1. The OEY of individual intercrops of both seasons was summed up to obtain overall system productivity of individual treatments.

[illegible]

Water productivity (kg m^{-3}) was calculated as water quantity applied (rainfall + irrigation) in each treatment divided by the obtained yield (Eq.2).

[illegible]

The economic analysis was carried out by considering the actual expenditure incurred on various operations, labour charges, prevailing market price of inputs and crop produce. The benefit: cost ratio was calculated dividing net returns by the cost of cultivation of individual treatment. The data recorded on various attributes were subjected to Fisher's method of analysis of variance and interpretation of data was taken up as per Sukhatme and Amble (1995).

Results and Discussion

Growth of pomegranate

Intercropping has positive effect on pomegranate plants as it improved the height, girth and canopy spread over sole plantation (Table 1). Average increase in height of pomegranate with radish-cowpea and onion-Indian squash cropping system was 37.1 and 46.6 %, respectively as compared to 21.3 % in sole pomegranate. Similarly, percent increase in girth and canopy spread of pomegranate was 65.0 and 20.2 % with radish-cowpea and 81.9 and 32.2 % with onion-Indian squash cropping system as compared to 45.5 and 8.8 %, respectively in sole pomegranate. The intercropping systems in pomegranate helps in improving microclimatic conditions, receiving the additional inputs, increase their use efficiency and improve soil environment through soil cover as compared to sole plantations in which the interspaces were left uncultivated and did not receive any additional inputs in terms of fertilizer, supplemental irrigation, additional biomass, *etc*. (Panda *et al*., 2003). The intercropping of the system becomes more useful in arid region with poor soil texture, low in soil organic carbon and available nutrients. Under such conditions, a minimal amount of additional nutrients through fertilizers, biomass return and irrigation help in better growth and development of associated plants. The positive effects of intercrops on vegetative growth of fruit trees have been reported by other workers in citrus (Yadava *et al.,* 2013; Yadava *et al.,* 2017), in sweet orange (Pal and Tarai, 2015), in aonla (Awasthi *et al.*, 2009), in ber (Saroj *et al.,* 2003; Yaragattikar and Itnal 2003; Birbal *et al*., 2013) and pomegranate (Soni *et al.*, 2020).

Yield of intercrops

Productivity (yield per unit area) of both *rabi* and *kharif* season crops increased with pomegranate as compared to their sole cropping (Table 2). But due to the sacrifice of the area covered with canopy of trees, it resulted in overall decline in yield on hectare basis. The yield of crops *viz*. onion (32900 kg/ha) and radish (21900 kg/ha) in *rabi* season and cowpea (391 kg/ha in *kharif* season) was less in intercropping systems as

Table 1. Growth of pomegranate in pomegranate based agri-horti system (values are ± standard error)

	Nov., 2015	Nov., 2016	% increase
	Height (cm)		
Sole pomegranate	122 ± 1.01	148 ± 0.97	21.3
Pomegranate + radish -cowpea	124 ± 0.93	170 ± 0.81	37.1
Pomegranate + onion -Indian squash	120 ± 1.46	176 ± .41	46.6
	Girth (cm)		
Sole pomegranate	10.17 ±0.13	14.8 ± 0.11	45.5
Pomegranate + radish -cowpea	10.42 ±0.12	17.2 ±0.09	65.0
Pomegranate + onion -Indian squash	9.95 ± 0.15	18.1 ± 0.10	81.9
	Average canopy spread (cm)		
Sole pomegranate	113.7 ± 1.41	123.8 ± 1.37	8.8
Pomegranate + radish -cowpea	118.6 ± 0.95	142.6 ± 0.92	20.2
Pomegranate + onion -Indian squash	112.8 ± 1.14	149.2 ± 1.08	32.2

Table 2. Yield of different vegetable crops grown as sole and in association with pomegranate

Treatments	Yield (kg/ha)			
	Rabi		Kharif	
	Veg. / Grain yield	Straw yield	Veg. / Grain yield	Straw yield
Pomegranate + onion - Indian squash	32900 ±872	--	25500 ± 813	---
Pomegranate + radish - cowpea	21900 ±558	--	391 ±14	574 ±19
Sole onion - Indian squash	34200 ±1010	--	24500 ±714	---
Sole radish - cowpea	25300 ±843	--	435 ±12	655 ± 22
Sole pomegranate	--	--	--	--

System productivity

The system productivity was calculated in terms of onion equivalent yield (OEY). The maximum OEY (63.6 t ha^{-1}) was observed in sole onion-Indian squash system which was at par with pomegranate + onion-Indian squash inter-copping system (Fig 1). However, OEY of pomegranate + radish-cowpea intercropping was lower (20.2 t ha^{-1}) as compared to sole plantations (23.1 t ha^{-1}) with a reduction in total productivity of the system by 12.4 per cent. This shows that during establishment phase of pomegranate orchard, onion-Indian squash can be a better option than sole plantations.

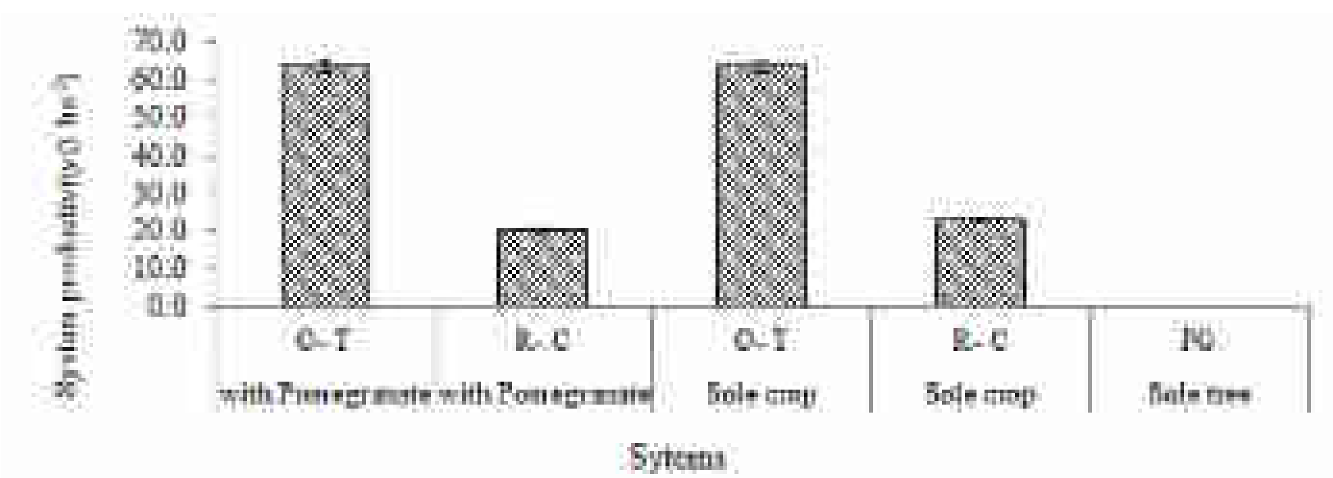

Fig. 1. System productivity (**a**nnual) of different systems in terms of onion equivalent yield (OEY, t ha^{-1}) (O= onion; T=Indian squash; R=radish; C=cowpea)

Water use and water productivity

Being long duration crop, maximum amount of water was applied in onion. Pomegranate + onion-Indian squash intercropping system consumed maximum amount of water followed by pomegranate + radish-cowpea intercrops system (Fig 2). Sole pomegranate received least amount of water. In pomegranate based intercropping systems water productivity in terms of economic yield (WP_{EY}) varied from 2.87-8.33 kgm^{-3}, respectively (Fig 3). In sole pomegranate, water productivity remained zero during its establishment phase because no economic yield was obtained, which can be improved to 2.87 and 6.71 kg m^{-3} in terms of WP_{EY} by incorporating intercrops of radish- cowpea and onion- Indian squash, respectively. Among all the systems, sole onion-Indian squash system showed highest WP_{EY} (8.33 kg m^{-3}). The water productivity in terms of gross return (WP_{GR}) varied from 130.5 to 452.7 Rs. ha^{-1} mm^{-1} (Fig 4). The Sole Onion-Indian squash cropping system registered maximum WP_{GR} (452.7 Rs. ha^{-1}mm^{-1}). During establishment phase of pomegranate orchard, the water productivity of sole pomegranate remained zero because no economic yield was obtained, which can be improved to 130.5 and 378.6 Rs. ha^{-1} mm^{-1} by incorporating intercrops of radish- cowpea and onion- Indian squash, respectively.

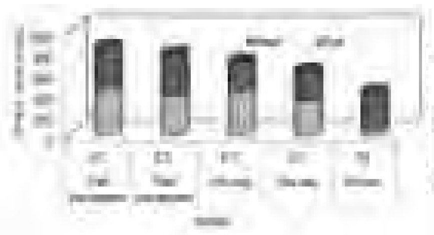

Fig. 2. Water applied in sole and intercropping systems with pomegranate

Fig. 3. Water productivity of different systems in terms of economic yield (WP_{EY})

Fig. 4. Water productivity of different systems in terms of gross return (WP_{GR})

Where O=onion; T=Indian squash; R=radish; C=cowpea; PG=pomegranate

Economic analysis

The economic analysis of different intercropping systems showed that onion- Indian squash produced higher gross return, net return and B:C ratio in both sole crops as well as in intercropping systems with pomegranate (Table 3). If we compare the sole pomegranate and intercropping system with pomegranate, an additional income of Rs. 2.36 lakhs ha^{-1} yr^{-1} can be obtained with pomegranate + onion- Indian squash and 0.49 lakhs ha^{-1} yr^{-1} with pomegranate + radish- cowpea intercropping system.

It could be concluded that intercrops promote the growth of pomegranate. Onion- Indian squash and Radish- Cowpea can profitably be cultivated in the inter space of pomegranate during establishment phase of orchard. Water productivity of sole orchard can be improved to 2.87 and 6.71 kg m^{-3} in terms of economic yield (WP_{EY}) and 3.05 and 6.71 kg m^{-3} in terms of biological yield (WP_{BY}) by pomegranate + Radish- Cowpea and pomegranate + Onion- Indian squash intercropping systems, respectively. The farmers can get additional income during the gestation period of fruit trees till they come in fruiting. However, the system needs to be assessed for longer term sustainability, productivity, profitability and soil health improvement.

Table 3. Economic performance of different systems grown as sole and in oleri-horti system

Treatments	*Cost of production (Rs./ ha)	Gross return (Rs./ ha)	Net return (Rs./ ha)	B:C ratio
Pomegranate + onion - Indian squash	81180	318000	236820	2.92
Pomegranate + radish - cowpea	51380	101200	49820	0.97
Sole onion - Indian squash	58700	318900	260200	4.43
Sole radish - cowpea	28900	115285	86385	2.99
Sole pomegranate	22480	-	-	-

*Cost of production includes only operational cost and does not include rental value of land, interest on working capital etc.

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