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Growth and yield of almond as influenced by rain water harvesting and mulching under rainfed condition

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ABSTRACT

Field demonstration trials were conducted for three consecutive years (2011 to 2013) to study the impact of rain water harvesting and mulching on rainfed almond production. There were 10 treatment combinations *viz.* T_1- half moon, T_2- half moon + organic mulch, T_3- half moon + plastic mulch, T_4- full moon, T_5- full moon + organic mulch, T_6- full moon + plastic mulch T_7- trench, T_8- trench + organic mulch, T_9- trench + plastic mulch, and T_{10}- control. The treatments were laid out in randomised block design with three replications. Results clearly indicated that significantly maximum mean plant height (6.40 m), TCSA (532.7 cm^2) and canopy spread (5.0 x 4.61 m), nut number (1277 $tree^{-1}$) and nut yield (3.73 kg $tree^{-1}$) were recorded in full moon water harvesting system + plastic mulch. Whereas, highest nut weight (3.08 g) was recorded in full moon system only. The productivity efficiency (7.0 $g^{-1}cm^2$ TCSA) was recorded in full moon water harvesting system + plastic mulch in almond under rainfed conditions of Kashmir valley.

1. INTRODUCTION

Almond (*Prunus amygdalus*) is one of the important nut crops of temperate region and belongs to the family Rosaceae. In India, it is mainly grown in the state of Jammu and Kashmir and Himachal Pradesh. The total area under almond cultivation is 21000 ha with annual production of 13000 t and average productivity is 0.62 t ha^{-1} in the country (NHB, 2013-14). Almond kernels are concentrated sources of energy with a significant share of fat, protein, and fibre. Commercial almond production in India is low considering the demand and economical potential. The low productivity is attributed to region specific technological interventions especially water management. The production and productivity may increase many fold if scientific production technologies are adopted for almond cultivation. The soil is sandy clay loam with poor drainage and receives average annual rainfall of about 700 mm out of which only 20-25% of total rainfall is received during May to July which is the critical period for nut growth and kernel filling. The erratic precipitation and constant droughts induced mainly due to climatic disturbance in the recent past have further aggravated the occurrence of low productivity of almond in this region. For improving the productivity of rainfed almond under changing climatic scenario, the conservation and utilization of rain water is of utmost importance which requires efficient water harvesting and conservation techniques. The rain water harvesting techniques like full moon, half moon and trench system combined with different types of mulches (Plastic and organic mulch) have been found effective in moisture conservation during critical stages of nut growth and kernel filling under rainfed condition (Kumar *et al.,* 2012). In the dry regions, water harvesting is considered among the excellent methods for productivity enhancement (Oweis and Hachum, 2006). Conservation measures for better growth and productivity were earlier advocated in apple (Kumar *et al*., 2013 and Kumar *et al*., 2014). Mulching plays an important role in soil moisture conservation, improving soil structure, regulation of soil temperature and reduces weed growth in litchi (Ganga *et al*., 2012), mango (Kumar *et al*., 2008), apple (Lal *et al*., 2003), plum (Sharma and Kathiravan, 2009) and almond (Verma *et al.*, 2001). However, no systematic work has been done on rain water harvesting and *in situ* moisture conservation aspect in almond under rain fed conditions of Kashmir valley. An experiment was conducted in order to identify suitable rain water harvesting technology in combination with mulching for rainfed almond production under temperate agro-ecological region of Jammu and Kashmir.

2. MATERIALS AND METHODS

The experiment was conducted at farmers fields of village - Nagam, Tehsil - Chadoora, District - Budgam of Jammu & Kashmir, India during 2011 to 2013 to study the effect of rain water harvesting and mulching techniques for almond production under rainfed condition. The variety which has been selected was seedling. The soil of this experimental field was sandy clay loam (61.3% sand, 12.4% silt and 26.3% clay); with a pH value 6.7. Average nitrogen and potassium content was 385.0 and 184.0 kg ha^{-1}, respectively with poor drainage. There were 10 treatment combinations *viz.* T_1- half moon, T_2- half moon + organic mulch, T_3- half moon + plastic mulch, T_4- full moon, T_5- full moon + organic mulch, T_6- full moon + plastic mulch T_7- trench, T_8- trench + organic mulch, T_9- trench + plastic mulch, and T_{10}- control. The treatments were laid out in randomised block design with three replications.

In half moon water harvesting system, semi-circular bunds, 30 cm width and 30 cm height at a radius of 3.0 m away from the tree trunk and 5% outward slope for rain water collection, were created at downstream side of the plant. In full moon water harvesting system, circular bunds, 30 cm width and 30 cm height at the radius of 3.0 m away from the tree trunk and 5% inward slope for rain water collection, were created around the periphery of the plant. There were earthing up around the tree trunk in the radius of 30-45 cm to avoid water stagnation around tree trunk. In trench water harvesting system, trench 30 cm width, 30 cm depth and 2.5 m length was created upstream side 1.5 m away from the tree trunk for collection of rain water from the catchment area. The plants were given uniform cultural treatment during the course of investigations. The rain water harvesting systems were created in almond field during 2011 and tree basins were covered with mulch as per the treatment. Black plastic mulch was UV resistant and cut in circular/semicircular/rectangular shape and slightly bigger than the size of the catchment area and laid in catchment area as per the treatment. The plastic sheets near the tree trunk and at the periphery of tree basin were placed beneath the soil to prevent being blown with wind. The polythene sheets were silted with 8-10 holes at equal distance to permit the rain water to enter into the soil. The locally available dry grass was collected and spread on soil surface in a layer in tree basin. The tree height was measured with the help of a long pole marked in m and spread was measured in two directions *i.e.* East-West and North-South and average spread was calculated and expressed in m. Tree trunk girth was recorded before the execution and at the end of experiment during the study. A ring was made with red paint at a height of 20 cm above the ground level in each selected tree to record the trunk girth from same point each year. The Trunk Cross-Sectional Area (TCSA) of tree was calculated by using $Girth^2/4\ л$ (Westwood *et al.,* 1970). Nut was harvested at maturity and yield $tree^{-1}$ was estimated in kg. The productivity efficiency ($g^{-1}cm^2$) was calculated by:

$$\frac{\text{Nut yield (g)}}{\text{TCSA (cm}^2\text{)}}$$

The data were analyzed statistically as per the standard procedure described by Gomez and Gomez (1984) for interpretation of results and drawing conclusions.

3. RESULTS AND DISCUSSION

Vegetative Growth

The vegetative growth such as plant height, TCSA and canopy spread (E-W and N-S) as influenced by rain water harvesting and mulching in almond under rainfed conditions is presented in Table 1. The growth parameters *viz.,* plant height, TCSA and canopy spread increased over the years in all the treatments. The maximum plant height was recorded in full moon water harvesting system+ plastic mulching which is significantly superior to half moon and trench water harvesting system. The treatment full moon + plastic mulch system increased plant height by 20.0% in 2011, 19.58% in 2012 and 20.28% in 2013 over the control plots. The mean maximum plant height (6.40 m) was recorded in full moon water harvesting system + plastic mulch which is significantly superior over control treatment.

The trunk cross sectional area (TCSA) of tree is one of the important parameters to predict the yield in almond. The maximum TCSA was recorded in full moon water harvesting system + plastic mulch (515.2 cm^2) followed by full moon + organic mulch (499.3 cm^2) and half moon + plastic mulch (496.2 cm^2) in 2011. Similar increasing trends were recorded in 2012 and 2013. The TCSA increases 24.35% in 2011; 22.89% in 2012 and 22.73% in 2013 over Control plots. The mean maximum TCSA was recorded in full moon water harvesting system + plastic mulch and it was increased by 23.28% over Control treatment.

Significantly higher canopy spread 47.64 x 27.56% in 2011; 50.74 x 27.74% in 2012 and 42.66 x 22.95% in 2013 was recorded in full moon water harvesting system + plastic mulching over control treatment. The mean maximum canopy spread (5.0 x 4.61m) was recorded in full moon water harvesting system + plastic mulch followed by full moon + organic mulching (4.71 x 4.53 m) and minimum was in Control plots (3.41 x 3.66 m).

The vegetative growth such as plant height, TCSA and canopy spread were highest in full moon water harvesting system + plastic mulch might be due to more and uniform availability of soil moisture around the active root zone thereby increased the vegetative growth of the tree. Similar findings were reported by Kumar *et al*. (2014) and Dwivedi *et al.* (2000) while working on apple.

Table: 1
Vegetative growth as influenced by rain water harvesting and mulching in almond

Treatment	Plant height (m)				TCSA (cm^2)				Canopy spread (m)							
									East-West			North-South			Mean	
	2011	2012	2013	Mean	2011	2012	2013	Mean	2011	2012	2013	2011	2012	2013	E-W	N-S
Half moon (HM)	5.51	5.72	5.95	5.72	452.4	471.1	482.9	468.8	3.32	3.61	3.75	3.91	3.98	4.05	3.56	3.98
HM + Organic mulch (OM)	5.78	5.95	6.18	5.97	472.1	481.2	487.0	480.1	3.95	4.24	4.45	4.02	4.32	4.51	4.21	4.28
HM + Plastic mulch (PM)	6.05	6.48	6.85	6.48	496.2	512.1	530.6	512.9	4.38	4.69	4.88	4.25	4.36	4.62	4.65	4.41
Full moon (FM)	5.72	5.95	6.24	5.97	481.1	492.6	512.2	495.3	4.02	4.32	4.54	4.15	4.42	4.58	4.29	4.38
Full moon + OM	5.94	6.05	6.38	6.12	499.3	525.1	537.4	520.6	4.45	4.75	4.92	4.28	4.43	4.88	4.71	4.53
FM + PM	6.21	6.35	6.64	6.40	515.2	535.2	547.9	532.7	4.71	5.05	5.25	4.35	4.65	4.82	5.00	4.61
Trench	5.44	5.77	5.98	5.73	422.1	462.1	485.0	456.4	3.52	3.61	3.92	3.68	3.91	4.24	3.68	3.94
Trench + OM	5.94	6.18	6.29	6.13	445.5	475.5	492.7	471.2	3.78	4.13	4.31	3.95	4.23	4.36	4.07	4.18
Trench + PM	6.19	6.35	6.52	6.35	461.2	481.2	512.2	484.8	4.15	4.34	4.35	4.16	4.48	4.62	4.28	4.42
Control	5.09	5.31	5.52	5.31	414.3	435.5	446.4	432.1	3.19	3.35	3.68	3.41	3.64	3.92	3.41	3.66
CD at 5%	0.61	0.52	0.68	0.60	48.2	46.4	47.5	47.4	0.71	0.75	0.72	0.47	0.54	0.45	0.52	0.49

Nut Yield and Contributing Characters

The data pertaining to nut number, weight and yield as influenced by rain water harvesting and mulching is presented in Table 2. The highest nut number (1355 tree^{-1}) was recorded in full moon water harvesting system+ plastic mulch followed by trench + plastic mulch (1255 tree^{-1}) and full moon + organic mulch (1244 tree^{-1}), in 2011. The nut number in the year 2012 was 33.3 to 42.7% less in all the treatments as compared to 2011 and again the nut number increased in 2013 in all the treatments. The mean maximum nut number (1277 tree^{-1}) was recorded in full moon water harvesting system + plastic mulch treatment which was superior to all other treatments.

Maximum nut weight (2.99 g) was recorded in full moon water harvesting system followed by trench system (2.92 g) and half moon + plastic mulch (2.89 g), in 2011. In 2012, there was a marginal increase in the nut weight in all the treatments which again came down in the year 2013. The mean nut weight (3.08 g) was recorded in full moon water harvesting system followed by full moon + organic mulch (3.06 g) and trench (2.99 g), respectively. The maximum nut weight was recorded in full moon water harvesting system might be due to more food diverted for development of less number of fruit per tree. An increase in carbohydrate levels leads to the increase in reproductive growth *i.e.* fruit weight (Khan, 1998).

The yield tree^{-1} is one of the important parameters as influenced by rain water harvesting and mulching in almond. Maximum nut yield (3.85 kg tree^{-1}) was recorded in full moon water harvesting + plastic mulch and minimum was in Control (2.12 kg tree^{-1}) treatment. The yield tree^{-1} marginally came down in 2012 and again increased in 2013 in all the treatments. The mean maximum yield tree^{-1} (3.73 kg tree^{-1}) was recorded in full moon water harvesting system + plastic mulch followed by full moon + organic mulch (3.46 kg tree^{-1}) and full moon only (3.38 kg tree^{-1}). Minimum mean nut yield (2.07 kg tree^{-1}) was recorded in Control treatment. The highest nut number and yield tree^{-1} was in full moon water harvesting system + plastic mulch, might be due to efficient weed control and fact that water after evaporation condenses on the bottom side of the polythene sheet and drop down again on the soil surface hence increase soil moisture during critical stages for proper nut growth and kernel filling. Raina (1992) also reported higher moisture content under black polythene mulch. These results are in accordance with the findings of Lal *et al*. (2003) and Kumar *et al*. (2013).

Productivity efficiency

Productivity efficiency was influenced by rain water harvesting and mulching in almond (Fig. 1). Maximum mean productivity efficiency (7.0 g^{-1} cm^2 TCSA) was recorded in full moon water harvesting system + plastic

Table: 2
Nut yield and its contributing characters as influenced by rain water harvesting and mulching in almond

Treatment	Nut number (tree^{-1})				Nut wt. (g)				Nut yield (kg tree^{-1})			
	2011	2012	2013	Mean	2011	2012	2013	Mean	2011	2012	2013	Mean
Half moon (HM)	997	706	1205	969	2.86	2.96	2.95	2.92	2.85	2.09	3.55	2.83
HM + Organic mulch (OM)	993	686	1125	935	2.97	3.12	3.10	3.06	2.95	2.14	3.49	2.86
HM + Plastic mulch (PM)	1080	778	1150	1003	2.89	3.01	2.98	2.96	3.12	2.34	3.43	2.96
Full moon (FM)	1130	869	1295	1098	2.99	3.14	3.12	3.08	3.38	2.73	4.04	3.38
Full moon + OM	1244	920	1350	1171	2.86	3.02	2.99	2.96	3.56	2.78	4.04	3.46
FM + PM	1355	1016	1460	1277	2.84	2.97	2.96	2.92	3.85	3.02	4.32	3.73
Trench	1027	674	1104	935	2.92	3.04	3.02	2.99	2.99	2.05	3.33	2.79
Trench + OM	1105	855	1125	1028	2.85	2.98	2.95	2.93	3.15	2.55	3.32	3.01
Trench + PM	1255	945	1175	1125	2.82	2.94	2.91	2.89	3.54	2.78	3.42	3.25
Control	778	545	891	738	2.73	2.87	2.85	2.82	2.12	1.56	2.54	2.07
CD at 5%	275	235	278	262	0.11	0.12	0.11	0.11	0.56	0.54	0.62	0.57

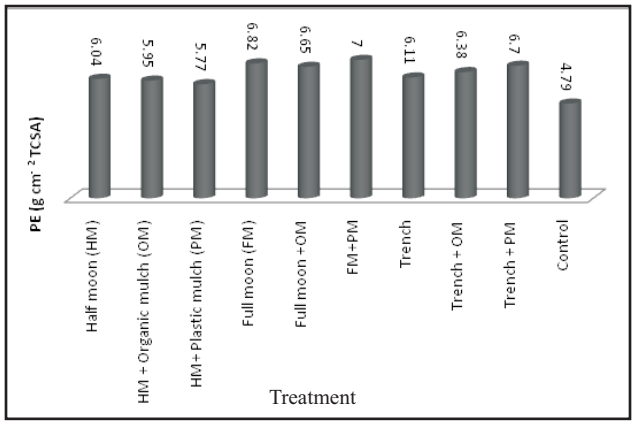

Fig. 1. Effect of rain water harvesting and mulching on productivity efficiency in almond

mulch followed by trench system + plastic mulch (6.7 $g^{-1}cm^2$ TCSA) and full moon water harvesting system + organic mulch (6.65 g^{-1} cm^2 TCSA) in almond under rainfed condition. The productivity efficiency was more in full moon water system + plastic mulch might be due to higher TCSA which leads to higher yield. The results are in conformity with the findings of Kumar *et al*. (2014).

4. CONCLUSIONS

The present study clearly suggested that rain water harvesting system like full moon, half moon and trench in combination with plastic mulch or organic mulch improves growth and nut yield of almond under rainfed conditions by enhancing the availability of soil moisture during critical stages of nut growth and kernel filling. It is a cost effective and economically viable technology for almond cultivation in resource poor areas of hill states.

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