Vol. 44, No. 1, pp 63-66, 2016
Indian Journal of Soil Conservation
Online URL:http://indianjournals.com/ijor.aspx?target=ijor:ijsc&type=home

In-situ rainwater harvesting strategies on soil properties, growth and yield of sunflower (*Helianthus Annuus* L.) in rainfed sodic soils of Northern Karnataka

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ARTICLE INFO

Article history :
Received : April, 2014
Revised : May, 2015
Accepted : June, 2015

Key words :
Gypsum,
In-situ rainwater harvesting,
Sodic soil,
Sunflower

ABSTRACT

An-farm experiment was carried out during *kharif* 2007-08 to 2010-11 on the effect of different rainwater harvesting practices along with gypsum application on soil properties, growth and yield of sunflower on sodic soil at Kyarihal village nearby Agricultural Research Station, Gangavati, Koppal district, Karnataka state. There were nine treatment combinations *viz*., T_1-Deep ploughing with 75% Gypsum Requirement (GR), T_2-Deep ploughing with 50% GR, T_3-Tied ridges with 75% GR, T_4-Tied ridges with 50% GR, T_5-Compartment bunding with 75% GR, T_6-Compartment bunding with 50% GR, T_7- Flat bed with 75% GR, T_8- Flat bed with 50% GR and T_9-Control (Flat bed without gypsum). The pooled data of four years revealed that significantly higher and lower moisture contents were recorded in the tied ridges with 75% GR and flat bed without gypsum at seed setting stage, respectively. Similarly, leaching of salts was higher under tied ridges, while lower under flat bed system as compared to other treatments. Significantly higher germination percentage, plant height and head diameter was found in T_3 and lower in T_9 treatments. Significantly higher seed yield (1.04 t ha^{-1}) was observed in T_3 followed by T_4 (1.0 t ha^{-1}) and least (0.58 t ha^{-1}) was recorded in T_9. However, significantly higher gross returns (₹ 31,200 ha^{-1}), net returns (₹ 21,500 ha^{-1}) and Benefit: Cost ratio (3.30) was obtained in T_3 and least in control (T_9).

1. INTRODUCTION

Soil salinity/sodicity is a universal problem both under dryland and irrigated agriculture. Out of 329 M ha of total geographical area in our country, the arid and semi-arid zones occupy more than one-third of the area (127.4 mha). The salt affected soils occurring in these zones occupy about 12 mha spread over 15 states of the country. These salt affected soils comprise of 4.12 mha of alkali soil, 3.26 mha of saline soil and 4.62 mha of saline alkali soils (Mahendra, 2007). In Karnataka, nearly 4.14 lakh ha of land is being affected by sodic problem (Gupta *et al*., 1995). Management of sodicity offers more challenges due to poor soil physical properties, crust formation, germination failure, low soil fertility, poor growth and low yield. These soils under dryland agriculture, therefore, require special skills to harvest rainwater so as to solubilize applied gypsum and facilitate leaching of sodium out of root zone. Sunflower (*Helianthus annuus L.*) is a traditional crop in northern Karnataka and is also known for tolerance to saline and sodic soils. To increase the productivity of sunflower in sodic soils under rainfed conditions, sodium should be leached out from root zone and more moisture is to be conserved for which effective *in-situ* rainwater harvesting structures are required.

Moisture, being the most limiting for growth and development in rainfed areas, needs to be conserved to the best advantage of crop plants. Higher soil moisture content due to compartment bunding was reported by Surkod and Itnal (1998), while similar results were observed due to adoption of tied ridges and furrows and compartment bunding as compared to flat bed method (Selvaraju *et al.,* 1999).

Information generated so far on reclamation and management of sodic soils showed that, these alkali lands can be put to crop production provided they are ameliorated through amendments. Among the amendments, gypsum is the cheapest and most convenient one for reclamation of sodic soils. Gypsum ($CaSO_4.2H_2O$) upon dissolution in soil solution, releases calcium which will replace excess Na on the soil exchange complex. The dissolution of gypsum as well as for the reaction to replace Na, soil moisture is crucial. Under rainfed situation, *in-situ* rainwater harvesting would greatly compliment the purpose of adding gypsum to the sodic soil. Therefore, this study was conducted to know the effect of gypsum application on soil properties and crop performance of sunflower under rainfed sodic soils under different *in-situ* moisture harvesting practices.

2. MATERIALS AND METHODS

An-farm experiment was carried out during *kharif* 2007-08 to 2010-11 (four years) in sodic soils with different *in-situ* rainwater harvesting structures for sunflower under rainfed sodic soils at Kyarihal village located 30 km away from Agriculture Research Station, Gangavati, Koppal, Karnataka. There were nine treatments combinations *viz*., T_1-Deep ploughing with 75% Gypsum Requirement (GR), T_2-Deep ploughing with 50% GR, T_3-Tied Ridges with 75% GR, T_4-Tied Ridges with 50% GR, T_5-Compartment bunding with 75% GR, T_6-Compartment bunding with 50% GR, T_7- Flat bed with 75% GR, T_8- Flat bed with 50% GR and T_9-Control (Flat bed without gypsum). The experiment was laid out in an area of 0.4 ha (15x10 m each treatment) with randomized block design with three replications. The experiment was initiated during *kharif* 2007-08 on sodic vertisol with initial physical properties *viz.,* hydraulic conductivity ranges from 0.10 to 0.15 m day^{-1} and bulk density rages between 1.40 to 1.43 g cc^{-1}, while chemical properties *viz.,* soil pH of 9.20, ESP of 23.10% and ECe of 2.2 dSm^{-1}. The land was prepared well by tillering and harrowing twice before the laid out of the experiment. The different *in-situ* moisture harvesting practices were constructed during the beginning of monsoon (June) and required gypsum was applied @ 12.0 t ha^{-1} (100%). The test crop was sunflower (private hybrid Ganga Kaveri) sown during *rabi* with the spacing of 60 x 30 cm and the performance of crop was evaluated. The crop was fertilized @ 60: 33: 50 kg NPK ha^{-1} applied twice and the necessary plant protection measures were taken as and when needed. The amount of rainfall received during the year 2006, 2007, 2008, 2009, 2010 and 2011 was 182.4, 817.9, 512.1, 1261.6, 722.3, and 411.2 mm, respectively. The amount of rainfall received during cropping period (October, November and December) of the year 2007, 2008, 2009 and 2010 was 56.3, 87.3 and 467.3 mm, respectively. The mean temperature and average rainfall for five years (2006-07 to 2010-11) of the study area were 40°C and 699.3 mm, respectively. The moisture content of the soil was measured by gravimetric method to know the moisture content at germination and seed setting stage. Soil samples were collected at depth of 0-60 cm and analysed for EC (1:2.5 soil water suspensions) and expressed as ECe after multiplying with appropriate correction factor (2.66) derived for the soil. Five plants were randomly selected in each treatment and tagged for recording growth and yield parameters. The crop was harvested in each net plot and it converted to yield ha^{-1} (t ha^{-1}). The growth and yield parameters were recorded at harvesting stage and statistically analyze by using Randomized Block Design (Gomez and Gomez, 1984). Economics was worked out based on market value of the produce and cost incurred for cultivation and benefit cost ratio was calculated by total gross returns divided by total cost of cultivation.

3. RESULTS AND DISCUSSION

Pooled data of four years on the effect of different land management practices on seed yield of sunflower differed significantly among treatments. Significantly higher seed yield (1.04 t ha^{-1}) was obtained in the tied ridges with 75% GR (Table 1) which was on par with tied ridges with 50% GR as compared to other treatments. However, Compartment bunding with 75% GR and Compartment bunding with 50% GR were on par at each other. Seed yield of sunflower was significantly lowest in case of flat bed without gypsum application (0.58 t ha^{-1}). The highest yield in tied ridges with 75% gypsum requirement is attributed to

Table: 1
Effect of different moisture conservation practices and amendment application on yield of sunflower

Treatments	Yield (t ha^{-1})				
	2007-08	2008-09	2009-10	2010-11	Pooled
T_1-Compartment bunding with 75% GR	1.0	0.76	0.85	0.96	0.89
T_2-Compartment bunding with 50% GR	0.97	0.75	0.83	0.89	0.86
T_3-Tied Ridges with 75% GR	1.15	0.89	1.0	1.11	1.04
T_4-Tied Ridges with 50% GR	1.12	0.86	0.96	1.04	1.0
T_5-Deep Ploughing with 75% GR	0.97	0.74	0.84	0.94	0.87
T_6-Deep Ploughing with 50% GR	0.93	0.71	0.81	0.86	0.83
T_7-Flat bed with 75% GR	0.81	0.62	0.73	0.81	0.74
T_8-Flat bed with 50% GR	0.78	0.58	0.65	0.76	0.69
T_9-Flat bed without gypsum (Control)	0.65	0.48	0.55	0.66	0.58
CD (*P*=0.05)	0.09	0.07	0.08	0.12	0.07

higher soil moisture content (Table 3) was observed at both germination and seed setting stage of sunflower. This could also be due to lower ESP that resulted in increased plant height and head diameter that in turn lead to increase in yield. The above results are in line with the findings of Allolli *et al.* (2008) who observed ridges and furrows with mulch treatment resulted in higher moisture retention in the soil as compared to flat bed method of cultivation and as evidenced by higher bean yield of cluster beans.

The higher seed yield of sunflower could also be attributed to higher growth and yield parameters. Head diameter and 100 seed weight were higher in tied ridges with 75% GR (14.0 cm and 4.80 gm, respectively) followed by tied ridges with 50% GR (13.70 cm and 4.70 gm, respectively). This higher head diameter and higher 100 seed weight could be due to higher plant height (155.1 cm) in tied ridges with 75% GR followed by tied ridges with 50% GR (152.30 cm), it was lowest in control (125.7 cm) (Table 2).

Soil moisture content, soil pH, soil ECe and ESP as influenced by application of gypsum and *in-situ* rainwater harvesting practices are presented in Table 3. The results revealed that at germination stage, higher soil moisture content (36.0%) was recorded in tied ridges with 75% GR and tied ridges with 50% GR (36.0%) followed by compartment bunding with 75% GR (35.3%). Similarly, at seed setting stage tied ridges with 75% GR (Fig. 1) recorded higher soil moisture content (30.0%) followed by tied ridges with 50% GR (29.50%) as compared to other treatments. This indicates that tied ridges with 75 or 50% GR are most effective in conserving soil moisture compared to other methods of moisture conservation practices (Table 3). This could be attributed to higher moisture retention in tied ridges due to standing of harvested water in between ridges during rainfall. The above results are in line with the findings of Subhas *et al*. (2009) who reported that highest moisture content was observed at the germination stage of sunflower in tied ridges and furrows under saline soil.

Soil chemical properties are also influenced by application of gypsum along with *in-situ* moisture

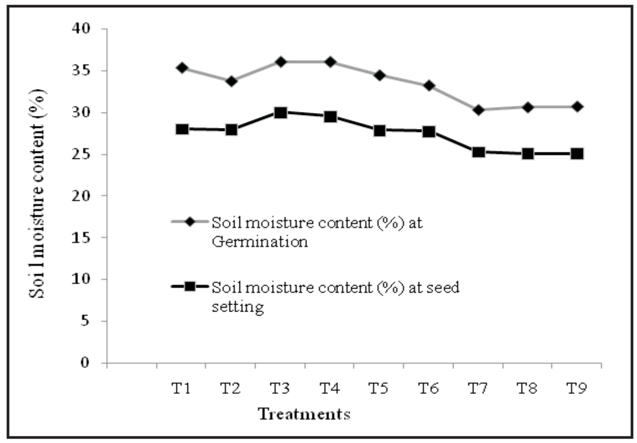

Fig. 1. Soil moisture content as influenced by different *in-situ* moisture conservation structures and gypsum application

Table: 2
Effect of different moisture conservation practices and amendment application on growth of sunflower (pooled over four years)

Treatments	Germination (%)	Head diameter (cm)	Plant height (cm)	100 seed weight (g)
T_1-Compartment bunding with 75% GR	90.4	12.2	145.3	4.7
T_2-Compartment bunding with 50% GR	88.5	11.6	143.5	4.6
T_3-Tied Ridges with 75% GR	93.9	14.0	155.1	4.8
T_4-Tied Ridges with 50% GR	92.6	13.7	152.3	4.7
T_5-Deep Ploughing with 75% GR	88.7	12.1	143.6	4.6
T_6-Deep Ploughing with 50% GR	87.1	11.8	141.4	4.5
T_7-Flat bed with 75% GR	81.4	10.5	128.3	3.6
T_8-Flat bed with 50% GR	79.4	10.1	127.8	4.4
T_9-Flat bed without gypsum (Control)	75.2	9.4	125.7	4.5
CD (P=0.05)	2.67	0.67	4.28	0.04

Table: 3
Soil moisture content, soil pH, ECe and ESP as influenced by different *in-situ* moisture conservation structures and gypsum application after harvest of sunflower (pooled data of four years)

Treatments	Soil moisture content (%)		Soil pH	Soil EC_e (dSm^{-1})	Soil ESP (%)
	At Germination	At seed setting			
T_1-Compartment bunding with 75% GR	35.3	28.0	8.74	1.93	16.1
T_2-Compartment bunding with 50% GR	33.7	27.9	8.82	1.75	18.3
T_3-Tied Ridges with 75% GR	36.0	30.0	8.65	1.78	16.4
T_4-Tied Ridges with 50% GR	36.0	29.5	8.78	1.78	19.0
T_5-Deep Ploughing with 75% GR	34.4	27.8	8.75	1.80	17.6
T_6-Deep Ploughing with 50% GR	33.2	27.7	8.82	1.70	19.8
T_7-Flat bed with 75% GR	30.3	25.2	8.94	1.75	21.5
T_8-Flat bed with 50% GR	30.6	25.0	8.98	1.83	21.8]
T_9-Flat bed without gypsum (Control)	30.7	25.0	9.12	1.83	22.5

conservation practices. The data indicated that the lower soil pH and soil exchangeable sodium percentage (ESP) was observed over the years. Among the treatments, the soil pH and ESP was less than the initial value (9.20 and 23.10%, respectively) in all the treatments (Table 3). Among the treatments, tied ridges with 75% GR and compartment bunding with 75% GR treatments recorded the least soil pH (8.65 and 8.74, respectively) and soil ESP levels (16.4 and 16.1%, respectively) when compared to other treatments. Whereas, not much decrease in soil pH and soil ESP was observed (9.12 and 22.5%) in control (flat bed without gypsum treatment). This could be attributed to higher soil moisture content in tied Ridges with 75% GR which might have resulted in reducing the soil ESP to the greatest extent (about 28%) compared to control. The above results are in conformity with the findings of Patel and Suthar (1993) who reported that gypsum application decreased the pH, EC and ESP of sodic soils of Junagadh (Gujarat) after the harvest of the bajra, groundnut and *jowar* crop from different locations.

Economic Analysis

Pooled data on cost of cultivation of sunflower under different *in-situ* moisture conservation practices and GR indicated that, higher cost of cultivation was recorded with compartment bunding with 75% GR (₹ 9,538 ha^{-1}) and lower cost of cultivation was noticed with flat bed without gypsum application (₹ 8,357 ha^{-1}). The additional cost incurred for individual treatment was higher in deep ploughing with 75% GR (₹ 23,950 ha^{-1}). However, the Gross returns (₹ 31,200 ha^{-1}) and net returns (₹ 21,500 ha^{-1}) were significantly higher in tied ridges and furrows with 75% GR which were closely followed by tied ridges with 50% GR (₹ 29,925 and ₹ 20,625 ha^{-1}, respectively). This in turn resulted in significant higher B:C ratio of 3.3 in both the treatments. Significantly increased seed yield could be the reason for enhanced B:C ratio in these treatments. The least gross return (₹ 17,550 ha^{-1}), net return (₹ 9,050 ha^{-1}) and benefit: cost ratio (2.1) was observed in Control treatment (Table 4). Though the net return in T_4 was slightly less than T_3, the B:C ratio was found to be similar (3.3) to that of T_3.

Table: 4
Gross returns, Net returns and B:C ratio as influenced by different moisture harvesting practices and amendment application (pooled over four years)

Treatments	Cost of cultivation (₹)	Additional cost for 4 years (₹)	Gross returns (₹)	Net returns (₹)	B:C ratio
T_1-Compartment bunding with 75% GR	9538	22750	26700	17000	2.8
T_2-Compartment bunding with 50% GR	9188	16500	25725	16425	2.8
T_3-Tied Ridges with 75% GR	9455	23550	31200	21500	3.3
T_4-Tied Ridges with 50% GR	9068	17300	29925	20625	3.3
T_5-Deep Ploughing with 75% GR	9348	23950	26175	16475	2.8
T_6-Deep Ploughing with 50% GR	9194	17700	24825	15525	2.7
T_7-Flat bed with 75% GR	9281	21950	22275	12575	2.4
T_8-Flat bed with 50% GR	9065	15700	20850	11550	2.3
T_9-Flat bed without gypsum (Control)	8357	3200	17550	9050	2.1
CD (P=0.05)	-	-	381.03	544.33	

Note : Rate of gypsum @ ₹ 100 bag^{-1}, cost of men labour @ ₹ 80 day^{-1} and price of produce @ 2992 $quintal^{-1}$

4. CONCLUSIONS

To get higher yield of sunflower by retention of rain water in soil through constructing tied ridges in the field prior to the onset of south-west monsoon along with application of gypsum @ 50% GR was found to be ideal under rainfed sodic vertisols for increasing sunflower yield as evidenced by the higher soil moisture content (36 and 38%) at germination and seed setting stage, respectively. The seed yield and B:C ratios in tied ridges with 75% GR and tied ridges with 50% GR were on par. It may be concluded that the Tied ridges with 50% GR are ideal for rainfed sodic soils.

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