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INFLUENCE OF SOIL AND MOISTURE CONSERVATION MEASURES AND CROPPING SYSTEMS ON SOIL NUTRIENT STATUS AND UPTAKE OF MAJOR AND MINOR NUTRIENTS IN MODEL WATERSHED DHARWAD

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ABSTRACT

A field experiment was conducted during *kharif* and *rabi* seasons of 2010-11 and 2011-12 to study the effect of soil and moisture conservation measures and cropping systems on soil nutrient status and uptake of major and minor nutrients in Dharwad model watershed. Pooled data indicated that, among the soil and moisture conservation measures broad bed and furrow method recorded significantly higher maize equivalent yield (MEY) (9544 kg ha^{-1}) compared to conservation furrow (7961 kg ha^{-1}). However, farmers' practice recorded the lowest MEY (6073 kg ha^{-1}) than the other methods. In the different cropping systems followed, the groundnut-wheat cropping system recorded significantly higher maize equivalent yield (MEY) (9404 kg ha^{-1}) than other cropping systems and was followed by maize-chickpea cropping system (8228 kg ha^{-1}). The higher uptake of both major and minor nutrients were found in BBF and the uptake was vary with the cropping systems.

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INTRODUCTION

India harbours 17 per cent of the global population in only 2.3 per cent of the land mass supported by 4 per cent of the fresh water resources. Naturally, maintenance of food and water security for its entire people is more arduous task than any other country in the world. The net cultivable area in the country of around 140 million ha is remaining constant or even squeezing from the pressure of urbanisation, industrialization and infrastructure development for the ever increasing population. The loss of the productive soils is another concern. Around 5 billion tonnes of soil is washed away every year taking away with it 6 million tonnes of nutrients due to improper soil and water management practices.

The water scenario is also equally grisly. Per capita availability of water has drastically decreased from 5000 m^3 in the 1950's to a meagre 1656 m^3 in 2007 and is conjectured to be well less than the internationally prescribed level of 1700 m^3 to 1140 m^3 by 2050. Currently almost 80 per cent of this water is generally allocated to agriculture, but in all likelihood it could be cut down by 10-15 per cent due to demands from other sectors like domestic, industries, power etc. Population is another issue that needs to be addressed besides precise soil and water management for ensuring food security. Having considered all these, crop production is estimated to increase at a rate of 4 per cent in the coming decades, is possible only, if we are able to manage our soil and water judiciously in the face of changing climate – induced soil and water ecology (Sen, 2009).

Rainfed agriculture in India is characterized by low productivity, degraded natural resources and widespread poverty. Most of the people living in rural areas depend on agriculture. Many make their living on the natural resources and rainfed agriculture. It has however, been recognized that only through a holistic development like the watershed development programme, economic conditions of such people can be improved. Watershed is a risk reduction management approach, which aims at protecting the inhabitants of the poorly endowed fragile ecosystem from acute distress caused by recurring droughts. Watershed management is a process of formulating and carrying out a course of action that seeks to harness the potential of natural, agricultural and human resources of the area. It aims at providing resources that are desired by and suitable to the community.

Black soils constitute 23.1 per cent of rainfed lands in the country and possess great production potential. They are poor in organic matter and structure and suffer from higher expansion and shrinkage being alkaline, the soils disperse easily and the net result of all these unfavorable characteristics is the low infiltration rate (0.8 mm hr^{-1}). Thus, the effectiveness of the already inadequate rainfall (500 to 700 mm) is further reduced. Cropping in the kharif season is not possible due to scanty and uncertain rainfall. Generally, crops are sown in October and are grown on stored moisture as there is little or no post-sowing rainfall. Hence, moisture is the major constraint in crop production during this season. This constraint can be alleviated by effective moisture conservation practices (Channappa, 1994). High intensity rains during monsoon period and poor infiltration rate (8 mm hr^{-1}) in medium deep black soils of the region provide considerable scope for soil erosion and huge runoff. The estimates reveal that 12-15 tonnes of top fertile soil is eroded annually from each hectare of land. Besides, 20-25 per cent of annual rainfall is being lost as runoff (Belgaumi*et al*., 1991).The better way to reduce these loses is soil and moisture conservation measures such as broad bed and furrow, conservation furrow, ridge and furrow, compartment bunding, tied ridge and furrow, contour cultivation, *etc*., mainly aim at uniform distribution of moisture in inter terraced area and to check the possible sheet or rill erosion. The basic rule of soil and moisture conservation is to stretch the infiltration opportunity time, for increased rainfall use efficiency and drainage of excess rainfall safely out of the crop fields.

Cropping system is a management of natural and other farm resources for cropping activity in such a manner that their maximum efficiencies are harnessed to attain and sustain potential yield levels per unit of land area per unit time without causing any deterioration in quality of environment of any level of ecological hierarchy (Yadav *et al*.,1998). Cropping system approach, addresses the issues related to economic aspects of cropping activity, available resources and micro-environment at farm level in holistic manner. However, in practice mixed crop stand is a feature of rain-fed agriculture. This helps to distribute the risks of the seasonal adversities. But the system is more towards survival than sustained progress. The important contribution of cropping system research is to modify the traditional subsistence cropping systems into highly productive, remunerative and sustainable one.

With this background, a field experiment was carried out to study the "effect of soil and moisture conservation measures and cropping systems on soil nutrient status and uptake of major and minor nutrients in model watershed Dharwad".

MATERIALS AND METHODS

A field experiment was conducted during *kharif* and *rabi* seasons of 2010-11 and 2011-12 to study the effect of soil and moisture conservation measures and cropping systems on soil nutrient status and uptake of major and minor nutrients in model watershed Dharwad. The soil of the experimental field was medium deep black having pH of 7.3, with medium organic carbon 0.51 %, available N (312.14 kg ha^{-1}), P (24.53 kg ha^{-1}) and K (202.24 kg ha^{-1}). The average total rainfall for the area is 801.9 mm of which 60 per cent (475.1 mm), 22 per cent (203.8 mm) and 18 per cent (121.4 mm) are received during monsoon (June-September), post monsoon (October-January) and summer (February-May) seasons, respectively.The field experiment consisted of three soil and moisture conservation measures as a main plots *viz*,M_1: Broad bed and furrow (BBF) M_2: Conservation furrow (CF) and M_3: Farmers' practices (FP) and four cropping systems as a sub plots *viz*,CS_1: Maize-chickpea, CS_2: Soybean-sorghum, CS_3:Groundnut-wheat and CS_4: Maize + pigeonpea, totalling 12 treatment combinations which were replicated thrice and laid out in split plot design with each plot size of 16 m X 18 m.The BBF system consists of a relatively raised flat bed or ridge approximately 95 cm wide and shallow furrow about 55 cm wide and 15 cm deep. The BBF laid out on a grade of 0.4–0.8% for optimum performance. Furrow was done by an implement attached with two riders with a chain tied to ridges or a multipurpose tool carrier called "Tropicultor" to which two ridgers are attached and used for this operation before the beginning of the rainy season, another cultivation was done to control weeds and improve the shape of the BBF.Conservation furrow system includes a series of furrows are opened on contour or across the slope at 3-5 m apart. The furrows were made during planting time using country plough. Two to three passes in the same furrow made to obtain the required furrow size.In farmers' practice, the operations carryout as per cultivation practices followed by the farmers for various operations like ploughing by wooden plough, harrowing by blade harrow, sowing by using desi seed drill, inter cultivation using inter culture equipments, nutrient application by manually and also by behind plough, etc. This is followed for different crops. Observations on yield were taken from different cropping systems and made for Maize Equivalent Yield (MEY), soil nutrient status and uptake of major and minor nutrients were recorded after harvest of the crops during both kharif and rabi season respectively.

The maize equivalent factor was calculated from the ratio of price per unit weight of the concerned crop by the price per unit weight of maize (Lal and Ray, 1976 and Verma and Modgal, 1983).

RESULTS AND DISCUSSION

Maize equivalent yield (MEY) of cropping systems (cf. Table 1)

The data revealed that maize equivalent yield (kg ha^{-1}) was significantly influenced by soil and moisture conservation measures. Broad bed and furrow method recorded significantly higher maize equivalent yield (MEY) (10884, 8203 and 9544 kg/ha) compared to conservation furrow (9469, 6454 and 7961 kg/ha) and farmers' practice during the both the years and pooled data, respectively. However, farmers' practice recorded the lowest MEY (7198, 4949 and 6073 kg/ha) than the other methods during 2010, 2011 and pooled data, respectively. The increased maize equivalent yield in broad bed and furrow attributed to higher soil moisture available for crop growth throughout the growing season and higher amount water infiltration into soil and less runoff by which nutrient loss could be reduced and more amount of water could infiltrate into the soil profile, which might have reflected in higher growth and yield parameters leading to higher maize equivalent yield. Similar results were reported by several research workers viz Arulkumar *et al*. (2005) (in CF), Patil *et al*.(2011), Devvrat*et al*. (2011) and Sakthivel*et al*.(2003)

Effect of cropping systems

The groundnut-wheat cropping system recorded significantly

Table 1: Maize equivalent yield of cropping systems as influenced by soil and moisture conservation measures

Treatment	Maize equivalent yield (kg ha^{-1}) 2010	2011	Pooled
Main plot: soil and moisture conservation measures			
M_1-BBF	10,884	8,203	9,544
M_2-CF	9,469	6,454	7,961
M_3-FP	7,198	4949	6,073
S. Em+	154	89	78
CD (P=0.05)	603	351	308
Sub plot: Cropping systems			
CS_1-M-C	8,613	7,843	8,228
CS_2-Soy-Sor	8,684	6,483	7,584
CS_3-G-W	12,858	5,949	9,404
CS_4-M + Pp	6,579	5,865	6,222
S. Em+	101	77	69
CD (P=0.05)	300	228	205
Interaction			
BBF x CS_1	10,029	9,700	9,865
BBF x CS_2	10,301	7,893	9,097
BBF x CS_3	15,247	7,880	11,564
BBF x CS_4	7,959	7,338	7,649
CF x CS_1	9,159	7,820	8,489
CF x CS_2	8,780	6,566	7673
CF x CS_3	13,485	6,020	9,753
CF x CS_4	6,452	5,408	5,930
FP x CS_1	6,651	6,009	6,330
FP x CS_2	6971	4,991	5,981
FP x CS_3	9,842	3,947	6,895
FP x CS_4	5,326	4,849	5,087
Cropping systems at same level of soil and moisture conservation measures			
S.Em+	175	133	120
CD (P=0.05)	909	395	355
Soil and moisture conservation measures at same or different cropping systems			
S.Em+	306	193	171
CD (P=0.05)	909	573	508

Note: BBF: Broad bed and furrow, CF: Conservation furrow and FP: Farmers' practice; CS_1: Maize – Chickpea, CS_2: Soybean- Sorghum, CS_3: Groundnut – Wheat and CS_4: Maize + Pigeonpea

higher maize equivalent yields (12,858 kg/ ha) during 2010. Whereas, during 2011, maize-chickpea cropping system recorded significantly higher MEY (7,843 kg/ha) than other cropping systems. Maize-chickpea and soybean-sorghum cropping systems recorded significantly higher MEY (8,613 and 8,684 kg/ha) in 2010 compared to maize + pigeonpea and were on par with each other. However, during 2011, soybean-sorghum cropping system recorded significantly higher MEY (6,483 kg/ha) than groundnut-wheat and maize + pigeonpea cropping systems. Further, in 2010, maize + pigeonpea cropping system recorded the lowest MEY (6,579 kg/ha) compared to all other treatments.

Pooled results showed that, groundnut-wheat cropping system recorded significantly higher MEY (9,404 kg/ha) than other treatments. Further, maize-chickpea cropping system was superior compared to soybean-sorghum and maize + pigeonpea. Similarly, soybean- sorghum cropping system recorded significantly higher MEY (7,584 kg/ha) compared to the maize + pigeonpea. However, maize + pigeonpea cropping system recorded the lowest MEY (6,222 kg/ha). The higher MEY obtained were attributed to the higher production efficiencies by the different cropping systems. Groundnut-wheat cropping system recordedsignificantly higher production efficiency (44.78 kg ha-1 day-1) compared to othercropping systems. The maize + pigeonpea cropping system recorded lowest productionefficiency (19.44 kg ha-1 day-1) among all cropping systems. Similar findings were reported by Kathmale *et al*. (2000) and Kumpawat (2001).

Interaction

Broad bed and furrow with groundnut-wheat cropping system during pooled data produced (Table 1) significantly higher MEY (11,564 kg/ha) as compared to all other cropping systems. The next best system was BBF with maize- chickpea cropping systems (9,865 kg/ha) and conservation furrow with groundnut-wheat cropping system (9,753 kg/ha). The farmers' practice with maize + pigeonpea cropping system recorded the lowest MEY (5087 kg/ha) than all other treatments. The results are in accordance with Sagare *et al*., 2001who reported the soil and moisture conservation through various practices has resulted in increased yield of various cropping systems under dryland (rainfed) conditions.

Available nutrients

Effect of soil and moisture conservation measures on available nutrients (major and minor) (Pooled data of Two year)

Among the different soil and moisture conservation measures, farmers' practice recorded significantly higher soil available

Table 2: Effect of soil and moisture conservation measures and different cropping systems on available soil nutrients

Treatment	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})	Sulphur (g ha^{-1})	Zinc (ppm)	Boron (ppm)
Main plot: Soil and moisture conservation measures						
M_1-BBF	231	12.4	238	5.3	0.77	0.69
M_2-CF	256	14.8	261	6.2	1.55	0.86
M_3-FP	280	22.0	296	7.2	3.33	1.31
S.Em+	3.87	0.80	6.52	0.17	0.10	0.02
CD (P=0.05)	15.19	3.13	25.62	0.66	0.39	0.07
Sub plot: Cropping systems						
CS_1-M-C	269	17.8	267	6.8	1.25	0.98
CS_2-S-S	254	13.9	260	6.1	2.81	1.06
CS_3-G-W	242	14.5	249	5.8	1.88	0.80
CS_4-M+Ppea	259	19.4	283	6.4	1.60	0.97
S.Em+	4.44	0.90	5.73	0.18	0.37	0.06
CD (P=0.05)	13.21	2.68	17.02	0.54	1.10	0.16
Interactions						
BBF x CS_1	241	13.5	239	5.9	0.75	0.80
BBF x CS_2	227	9.8	236	5.2	0.85	0.61
BBF x CS_3	217	11.7	224	4.6	0.77	0.64
BBF x CS_4	241	14.5	252	5.5	0.70	0.71
CF x CS_1	269	15.8	261	6.8	1.17	0.93
CF x CS_2	247	12.8	254	5.8	2.06	0.77
CF x CS_3	247	12.7	250	5.8	1.60	0.79
CF x CS_4	260	18.0	277	6.3	1.37	0.94
FP x CS_1	297	24.1	301	7.6	1.82	1.20
FP x CS_2	289	19.0	289	7.1	5.51	1.80
FP x CS_3	261	19.2	273	6.9	3.26	0.95
FP x CS_4	274	25.7	321	7.4	2.72	1.27
S.Em+	9.45	1.93	14.20	0.40	0.58	0.06
CD (P=0.05)	NS	NS	NS	NS	NS	0.16

Note: DAS: Days after sowing, NS: Non significant; BBF: Broad bed and furrow, CF: Conservation furrow and FP: Farmers' practice; CS_1: Maize – Chickpea, CS_2: Soybean- Sorghum, CS_3: Groundnut – Wheat and CS_4: Maize + Pigeonpea

nutrients both major and minor (280 kg N /ha, 22 kg P/ha, 296 kg K /ha, 7.2 g/ha, 3.33 ppm Zn and 1.31 ppm B.) over BBF during both the years and in pooled results and was followed by conservation furrow (256 kg N /ha, 14.8 kg P/ha, 261 kg K /ha, 6.2 g/ha, 1.55 ppm Zn and 0.86 ppm B).The broad bed and furrow recorded significantly the lowest soil available nutrients (231 kg N /ha, 12.4 kg P/ha, 238 kg K /ha, 5.3 g/ha, 0.77 ppm Zn and 0.69 ppm B) compared to all other treatments in pooled results.

It may be attributed to the lesser uptake by crops due to lesser available soil moisture throughout growing season as compared to BBF and also due to lower yield obtained in farmers' practice, even though nutrients were available, due to lack of moisture, crop could not use much and harsed to more available nutrients remained in soil leading to high available nutrient status in soil under farmers' practice.

Effect of cropping system on available nutrients (major and minor) (pooled data of two year)

Pooled data from table No-2,**c**ropping systems differ significantly. Among the cropping systems followed, maize-chickpea cropping system recorded significantly higher available N (269 kg/ ha) and Sulphur 6.8 g/ha over other cropping systems. Whereas, available P (19.4 P kg/ha) and K (283K kg/ha)were significantly higher in Maize + Pigeon pea cropping system compared to maize-chickpea cropping system. The significantly higher Zn (2.81 ppm) and B (1.06 ppm) were observed in soybean- sorghum cropping system. Wherever, the legume crop was grown either in *kharif* or in *rabi* seasons recorded significantly higher available nutrient in soil than with non-legume crops. This might be due to nodulation of legume crops which fixes atmospheric N leading to high soil N. As there is synergistic relation of N with P, K and S, it might have helped in increasing content of other nutrients in soil irrespective of nutrient management practices. This was in accordance with the findings of Kadam *et al.* (2010).

The interactions effects were non-significant with respect to soil and moisture conservation measures and cropping systems in pooled results.

Plant nutrient uptake

Effect of soil and moisture conservation measures on nutrients uptake (cf. Table 3)

The nutrient uptake is the function of nutrient content in grain, plant and their yields. The soil and moisture conservation measure plays very important role in reducing runoff by obstructing water flow and made more amount of water to infiltrate into soil profile, by which reduced nutrient loss through soil erosion which helped crops to record higher uptake of nutrients from the soil.

Among the soil and moisture conservation measures, broad bed and furrow recorded significantly higher N, P, K, S, Zn and B uptake (185 N kg/ha 26.4 P kg/ha and 109 K kg/ha, 186 g/ha, 2778 ppm Zn and 1219 ppm S) compared to farmers' practice during pooled data and followed by the conservation

Table 3: Effect of soil and moisture conservation measures and cropping systems on nutrients uptake

Treatment	N uptake (kg ha^{-1})	P uptake (kg ha^{-1})	K uptake (kg ha^{-1})	Sulphur (g ha^{-1})	Zinc (ppm)	Boron(ppm)
Main plot: Soil and moisture conservation measures						
M_1-BBF	185.1	26.4	109.3	186.65	2778	1219.3
M_2-CF	142.0	20.1	83.3	124.39	1973	864.1
M_3-FP	103.6	15.1	59.5	87.94	1324	600.4
S.Em+	1.03	0.15	1.09	16.54	64.41	14.51
CD (P=0.05)	4.03	0.58	4.29	64.94	252.92	56.98
Sub plot: Cropping systems						
CS_1-M-C	128.3	31.5	110.1	151.07	2555.5	912.1
CS_2-S-S	176.9	16.4	101.3	118.86	1968.9	1129.8
CS_3-G-W	164.1	16.2	58.4	173.17	1739.9	901.4
CS_4-M+Ppea	105.0	18.0	66.4	88.89	1836.7	635.1
S.Em+	2.89	1.43	2.20	20.20	51.42	49.06
CD (P=0.05)	8.60	4.25	6.55	60.01	152.77	145.76
Interactions						
BBF x CS_1	168.1	39.2	138.3	193.28	3466.4	1271.0
BBF x CS_2	220.6	21.3	133.7	153.84	2722.6	1499.1
BBF x CS_3	210.1	21.8	76.9	286.33	2460.2	1251.1
BBF x CS_4	141.7	23.2	88.2	113.18	2465.4	856.2
CF x CS_1	129.0	31.3	112.0	156.57	2587.8	933.1
CF x CS_2	173.4	15.7	98.2	116.55	1867.2	1051.7
CF x CS_3	168.7	16.2	59.5	137.94	1655.0	888.1
CF x CS_4	97.0	17.1	63.5	86.51	1782.3	583.6
FP x CS_1	87.8	24.0	79.9	103.36	1612.3	532.3
FP x CS_2	136.8	12.1	71.8	86.19	1317.0	838.6
FP x CS_3	113.5	10.5	38.7	95.25	1104.4	565.1
FP x CS_4	76.2	13.7	47.5	66.97	1262.5	465.5
S.Em+	4.69	2.48	3.81	41.69	135.63	77.76
CD (P=0.05)	NS	NS	NS	NS	402.98	NS

Note: DAS: Days after sowing, NS: Non significant ; BBF: Broad bed and furrow, CF: Conservation furrow and FP: Farmers' practice; CS_1: Maize – Chickpea, CS_2: Soybean- Sorghum, CS_3: Groundnut – Wheat and CS_4: Maize + Pigeonpea

furrow (142 N kg/ha 20.1 P kg/ha and 83.3 K kg/ha, 124.39 g/ ha, 1973 ppm Zn and 864.1 ppm S). Farmer Practice recorded significantly lower uptake of major and mine nutrients. Similar findings have been reported by Kiran *et al.* (2008) who has observed that among *in-situ* moisture conservation practices, ridges and furrows and compartmental bunding were found beneficial in conserving higher soil moisture and resulted in higher grain yield of *rabi*sorghum (15.78 and14.96 q ha-1, respectively) compared to flatbed method of sowing (11.74 q ha-1).Among *in-situ* moisture conservation practices, ridges and furrows recorded higher nitrogen content [leaf (0.45%), stem (0.32%), grains (1.32%) and total nitrogen content(2.08%)] and nitrogen uptake (leaf, stem, grains and total nitrogen content) as compared to other practices.The studies conducted by Pratap Singh and Verma (1996) at Bichpuri also revealed that the ridge and furrow sowing method significantly increased N uptake in pearl millet grain, stover as well as total uptake. On an average ridge and furrow method increasedN uptake by 25.2, 24.2 and 23.1 per cent through grain, stover and total, respectivelyover flat sowing.Mathukia*et al.* (2016)also revealed that in-row subsoiling and broad bed and furrow reduced bulk density, conservedmore soil moisture and significantly enhanced growth and yield attributes and nutrient uptake,

Effect of cropping systems on nutrients uptake (cf. Table 3)

Pooled data of two year indicated that, among the major nutrients, uptake of N was significantly higher in Soybean-Sorghum system (176.9 kg/ha) whereas Phosphorus uptake was higher in Maize + Pigeon pea cropping system (18.0 kg/ ha) compared to rest of the treatments. The significantly higher uptake of Potassium was observed inmaize-chickpea cropping system (110.1 kg/ha).

The uptake of micro-nutrients were varied with the different treatments, among the cropping systems, Sulphur uptake was significantly higher in Groundnut - Wheat cropping system (173.17 g/ha) whereas, Zinc uptake was significantly higher in maize-chickpea cropping systems (2555.5 ppm) over other treatments and the significantly higher Boron uptake was observed in Soybean- Sorghum system (1129.8 ppm).

Inclusion of pulses in intensive agriculture is beneficial, as these crops improve the soil fertility and crop productivity (Yadav, 1988, Tomar*et al.*, 1990 and Gupta and Rai, 1990). Inclusion of *kharif*legumes in cropping system have more benefits (Jawale*et al.*, 1998). The benefit of including legumes in cropping system improves soil fertility (Ramesh *et al.*, 2008 and Das *et al.*, 2010). Similarly, Varalakshmi*et al.* (2005) reported that the legume crops increase the available N, P and K content of the soil and thereby more uptake of nutrients.

The interactions effects were non-significant with respect to soil and moisture conservation measures and cropping systems in pooled results.

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