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Research Article

IMPACT OF SUBSURFACE DRAINAGE SYSTEM ON SOIL CHEMICAL PROPERTIES AND CROP YIELD IN UPPER KRISHNA COMMAND

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Abstract- A study was conducted to check the impact of subsurface drainage system on salt affected soils in the UKP command, Karnataka. The mean pH of samples ranged from 8.21 to 8.71 before sowing to 8.58 to 8.95 after harvesting and before sowing the electrical conductivity ranged from 8.84 to 12.09 dS m^{-1} and 7.25 to 12.06 dS m^{-1} after harvesting. Similarly, the Ca^{2+}+Mg^{2+}, Na^{+} and K^{+} values were in the range of 34.68 to 39.76, 7.80 to 10.92 and 0.12 to 0.16 Meq/100g before sowing of crops, after harvesting of the crops results obtained were in range of 34.44 to 37.62, 7.10 to 9.40 and 0.20 to 0.27 Meq/100g. The ESP values were in the range of 17.99 to 21.45 before sowing and 17.07 to 19.90 after harvesting of crop. A glance at an results reveals that pH and K^{+} was observed to be increased due to sodic nature of soil and excess application of the fertilizer. ESP was noticed to be reduced in smaller amount as compared to pre-sowing conditions, gypsum needed to be applied in required amount in order to turn the soil from sodicity to saline or non-saline soils. Finally, the yield was observed to be 62.00 q ha^{-1} as compare to pre drainage conditions of 42.01 q ha^{-1}.

Keywords- Soil reaction, Electrical conductivity, Exchangeable cations and crop yield.

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Introduction

Agriculture plays a vital role in the Indian economy with its large resources of land, water and sunshine. Despite the focus on industrialisation, agriculture remains a dominant sector of the Indian economy both in terms of contribution to gross product as well as a source of employment to millions across the country. The Indian agriculture sector accounted for 13.7 per cent of India's gross domestic product and employed just a little less than 60 per cent of the country's workforce in 2013. The statement "Agriculture Sustains Life, but Irrigation Sustains Agriculture" is true for India. The spectacular development of irrigation since independence in India is unparalleled in the world; which has greatly boosted the agricultural production. Irrigation development in India, with a mere 22.7 M ha during 1950 has gone up to 114.8 M ha at present. However, the same attention has not been given to land drainage to create conductive atmosphere to the crop growth. As a result, the impact of irrigation over decades due to the absence of appropriate drainage measures and unscientific land and water management practices over the years have led to groundwater table rise to nearby or at root zone. The water table rise also brings up salts with it from subsurface thereby rendering salinity in the root zone. According to the FAO Land and Plant Nutrition Management Service, a significant proportion of cultivated land is salt-affected globally. Of the current 230 M ha of irrigated land, 45 M ha are waterlogged and salt-affected[19.5%] and of the 1,500 M ha under dry land agriculture, 32 M ha are salt-affected. It is estimated that up to 20 per cent of irrigated land in the world is affected by different levels of salinity and sodium content [1]. In India about 12 M ha of land area is affected by water logging and soil salinity from Kashmir to Kanya kumari and from east to west. If the natural drainage is insufficient to remove excess water and salts away from an affected area, the subsurface drainage technology has been used for reclamation of water logged and salt affected lands in many parts of the country, the system mainly consists of corrugated perforated PVC drain pipes and synthetic materials as drain envelope. The areas with drainage system soil conditions improved significantly and yield of paddy, sugarcane, betel vine and turmeric increased by 30, 19, 30 and 11 percent, respectively as compared to the yield obtained from the fields that were not drained [2]. The Agricultural Research Station, Malnoor is one of the 12 Agricultural Research Stations coming under the jurisdiction of the newly established University of Agricultural Sciences Raichur, Karnataka during 2009. The farm consists of a total area of about 165 ha and an extent of about 55 ha was affected by the problems of water logging and salinity leading to under productivity of crops. In order to tackle the problems of Water logging and salinity the subsurface drainage system was installed in an area of 10.65 ha.

MaterialsandMethods

Study area and climate

The area selected for the present study comes under the command of Narayanapur Left Bank Canal [NLBC] of UKP and is located in the Agricultural Research Station [ARS] Farm, Malnoor of the University of Agricultural Sciences Raichurat a distance of about 7 km from Hunasagi in Shorapurtaluk, Yadgir district, Karnataka. The project area lies at 170 03' N latitude and 76015'E longitude at an elevation of 460 m above the mean sea level. The annual average rainfall of the nearest rain gauge station at Hunasagi is 547.1 mm. The soils present in the study area are predominantly vertisols shallow to medium black soils and the texture of top soil is sandy clay loam, while the lower soils are clay loam. The clay content of the soil generally ranged from 32 to 41 per cent. The geology of the area consists of horizontally bedded limestone underlain by close pet and other granites.

Observations recorded

In order to carry out systematic studies, the sampling points were identified on a grid size of 50 m X 50 m in the study area [30 points]. The soil samples were collected at different depths of 0-30, 30-60, 60-90 and 90-120 cm in these grid points before sowing and after harvesting. The chemical analysis included estimating pH, EC, K^+, Na^+, Ca^{2+}, Mg^{2+}, ESP by adopting standard procedures to know the salinity and sodium level etc. The comparison of soil salts content before sowing and after harvesting of crop was carried out using paired t-test and F test was conducted to check the concentration of salts at particular depths but at different points.

Results and Discussion

Effect of sub-surface drainage on soil properties

Soil reaction

The Data presented in [Table-1] reveals that the mean pHs values ranged from 8.21 to 8.71 before sowing. Similarly, the mean pHs values after the harvesting varied from 8.58 to 8.95. The mean pH value before sowing and after harvesting was observed to be increasing as the depth increases. it could be noticed from the [Table-1] that F_{cal} value 12.31* and 6.54* was more than that of the F_{cri} value [2.68], which implied that there was significant difference between the mean pHs values drawn from different depths before sowing and after harvesting. A close examination of the same revealed that t_{cal} values [-13.46, -15.56, -11.46 and -10.60 respectively] for the soil samples drawn from 0-30, 30-60, 60-90 and 90-120 cm depths at different grid points before sowing and after harvesting were more than the t_{cri} value 1.699 [Table-2]. This indicated that there was significant difference between the mean pHs values of soil samples drawn at different depths before sowing and after harvesting of the crop. There was no pronounced effect of SSD system alone in reducing the soil pHs. Before sowing the soil from 0-60 cm depth showed saline-sodic characteristics and from 60-120 cm depth exhibited sodic characteristics, but after the harvesting, the entire depth of soil from 0-120 cm became sodic. In such cases, gypsum also should have been applied as amendment particularly to sodic soils, which would have reduced the sodicity of the soils considerably. Therefore, gypsum needs to be applied to the sodic portion of the affected area to quicken the process for complete reclamation of land. These observations were in line with the past studies, which revealed that the pHs of the soil after the implementation of the subsurface drainage system increased [3-5].

Electrical conductivity [ECe]

The analysis of salinity of the soil samples observed before sowing and after harvesting of the crop are presented in [Table-1]. The mean ECe ranged from 8.84 to 12.09 dS m-1 in the soil samples collected before sowing. Similarly, after harvesting of crop the ECe was observed to be in the range of 7.25 to 12.06 dS m-1. It could be seen that F_{cal} value 6.53* and 4.79 was more than that of the F_{cri} value [2.68], implying that there was significant difference between the mean ECe values of soil samples drawn from different depths before sowing and after harvesting. A scrutiny of the same indicated that t_{cal} values [12.46, 12.10, 5.39 and -1.96 respectively] for the soil samples drawn from 0-30, 30-60, 60-90 and 90-120 cm depths at different grid points before the sowing and after the harvesting were more than the t_{cri} 1.699 [Table-2]. This showed that there was significant difference between the mean ECe values of the soil samples drawn before sowing and after harvesting at all depths. There was reduction in ECe by 7.38 to 66.75 per cent in 0-90 cm depth, while it increased by 36.43 per cent in 90-120 cm depth. This could be due to the fact that the salts got accumulated more at the surface layers in pre-drainage situation over a period of time due to development of water logging and salinity by excess flow of water along with salts and by the processes of high evaporative demands and capillary action. After the installation of SSDs, the paddy crop was taken up for cultivation. Due to this, the surface layer salts were partly leached to deeper subsurface layers due to impounding of water by rainfall and irrigation and by infiltration and deep percolation processes and were partly discharged out by drainage water through the laterals and the collector drains. Manjunath [6] noted that the average salinity in the top soil of the study area decreased from an initial value of 8.40 ± 0.80 to 2.60 ± 0.40 dS m^{-1} during *kharif* 1998 and further to 2.10 ± 0.50 dS m^{-1} during *rabi* 1998–1999. The harmful salts that were brought in by the irrigation water were also reduced to a level ranging from 1.20 to 35.40 dS m^{-1}[5].The results of the present study were in agreement with similar findings [7-9].

Exchangeable calcium and magnesium

An interpretation of the [Table-3] revealed that the mean exchangeable calcium and magnesium variations were in the range of 34.68 to 39.76 meq/100 g in the soil samples collected before sowing. Similarly, the mean exchangeable calcium and magnesium values in case of after harvesting varied from 32.91 to 37.62 meq/100 g. Moreover, it was noticed that F_{cal} value 15.75*and 13.48* was more than the F_{cri} value [2.68], hence there was significant difference between the mean exchangeable calcium and magnesium values of soil samples drawn from different depths before sowing and after harvesting. A glance of comparative analysis of exchangeable calcium and magnesium before sowing and after harvesting reveals that that t_{cal} values [7.22, 7.73, 3.48 and 4.86 respectively] for soil samples drawn from different depths were more than the t_{cri} 1.699 value [Table-4]. Thus, it could be concluded that there was significant difference in the mean exchangeable calcium and magnesium content of soil samples drawn before sowing and after harvesting. This was in line with the findings [4].

Table-1 *Impact of SSD system on soil pH and EC[dS m-1]*

Depths	Electrical conductivity		pH	
	Before sowing	After Harvesting	Before sowing	After Harvesting
0-30	12.09	7.25	8.21	8.58
30-60	11.17	8.40	8.38	8.71
60-90	10.16	9.41	8.53	8.81
90-120	8.84	12.06	8.71	8.95
F_{cal}	6.53*	4.79*	12.31*	6.54*
F_{cri}	2.68		2.68	

NS - Non Significant
* - Significant

Table-2 *Comparison of soil salinity before sowing and after harvesting of crop using paired t-test*

Depths	Electrical conductivity		pH	
	Tcal	tcri	tcal	tcri
0-30	12.46*	1.699*	-13.46*	1.699*
30-60	12.10*		-15.56*	
60-90	5.39*		-11.46*	
90-120	-1.96*		-10.60*	

NS - Non Significant
*Significant

Exchangeable sodium

The results from [Table-3] revealed that the mean sodium content values ranged from 7.80 to 10.92 meq/100g before sowing. Later after harvesting, the sodium content varied from 7.10 to 9.40 meq/100 g. The sodium content was observed to be decreases as the depth increases in both the cases before sowing and after harvesting. It was noticed that F_{cal} value were 24.11* and 22.11* which were more than that of the F_{cri}-value [2.68], and therefore it could be concluded that there was significant difference between the mean Na^+ values of soil samples drawn from different depths. The t_{cal} and t_{cri} values computed in comparison of exchangeable sodium content of soil before sowing and after harvesting of crop using paired t-test are presented in [Table-4]. This implied that there was significant difference between the mean exchangeable sodium content of soil samples obtained at various depths in different grid points. The soil exhibited higher exchangeable sodium content in the surface layer than that of the deeper layers due to higher evaporation and capillary rise of dissolved sodium in the summer season. With the ponding of water after the transplanting of the paddy crop, part of the sodium was dissolved in the water and drained away Though the drains were found working well, but not found much efficient in the reduction of the sodium concentration from the soil. Magnitudes of reduction in sodium content were recorded as 13.10 and 12.60 per cent at 60-90 and 90-120 cm drainage depths respectively [10].

Table-3 *Impact of SSD system on soil ESP and Exchangeable cations*

Depths	ESP		$Ca^{2+}+Mg^{2+}$		Na^+		K^+	
	Before sowing	After Harvesting	Before sowing	After Harvesting	Before sowing	After Harvesting	Before sowing	After Harvesting
0-30	21.45	19.90	39.76	37.62	10.92	9.40	0.16	0.27
30-60	21.02	19.67	37.01	34.74	9.91	8.68	0.14	0.25
60-90	19.90	18.83	34.68	32.91	8.66	7.67	0.12	0.22
90-120	17.99	17.07	35.50	34.44	7.80	7.10	0.12	0.20
F_{cal}	9.21	6.48	15.75	13.48	24.11	22.11	3.90	1.008^{NS}

NS - Non Significant * -Significant

Table-4 *Comparison of ESP and Exchangeable cations before sowing and after harvesting of crop using paired t-test*

Depths	ESP		$Ca^{2+}+Mg^{2+}$		Na^+		K^+	
	t_{cal}	t_{cri}	t_{cal}	t_{cri}	t_{cal}	t_{cri}	t_{cal}	t_{cri}
0-30	7.46*	1.699*	7.22*	1.699*	11.06*	1.699*	-5.03*	1.699*
30-60	5.64*		7.73*		10.56*		-6.27*	
60-90	4.06*		3.48*		7.50*		-6.71*	
90-120	5.31*		4.86*		6.13*		-7.17*	

NS - Non Significant *- Significant

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Exchangeable potassium

The results from [Table-3] revealed that the mean K values before sowing ranged from 0.12 to 0.16 meq/100g. The mean K values of soil samples observed after harvesting of the crop ranged from 0.20 to 0.27 meq/100 g. it was observed that the K values was found to be increased after harvesting of the crop. However, it was noticed that as the F_{cal} value were 3.90* was larger than the F_{cri} value [2.68], but after harvesting of the crop the F_{cal} 1.008 was found to be less than the F_{cri} value 2.68. It could be inferred that there was significant difference between the mean values of exchangeable potassium drawn from different depths before sowing bur no significant difference was observed after harvesting of the crop. Furthermore, it was seen that K^+ values decreased as the depth increased. A look at the results revealed that t_{cal} value[-5.03, -6.27, -6.71 and -7.17 respectively] of the soil samples drawn from 0-30, 30-60, 60-90 and 90-120 cm at different grid points before sowing and after the harvesting was numerically greater than t_{cri} value of 1.699. Hence, it could be concluded that there was significant difference between the mean exchangeable potassium content of soil samples drawn before sowing and after harvesting of the crop. The results of mean exchangeable potassium [K^+] values revealed that there was an increase in the potassium content in the soil after harvesting of the crop by 66.67 to 68.75 per cent as compared pre-sowing conditions [Tables-3]. This might be due to the excess application of the fertilizers to the field, even though smaller amount of potassium was leached out through the drains. These results were in confirmation with findings [10].

Exchangeable sodium percentage

The exchangeable sodium percentage [ESP] values of the soil samples before sowing and after harvesting drawn from different depths ranges from 17.99 to 21.45 and 17.07 to 19.90 [Table-3]. Also, since the F_{cal} values were 9.21* and 6.48* which were more than the F_{cri} value [2.68], there was significant difference between the mean values of ESP drawn from different depths before sowing and after harvesting. The data from [Table-4] revealed that t_{cal} value [7.46, 5.34, 4.06 and 5.31] for the soil samples drawn from 0-30, 30-60, 60-90 and 90-120 cm depths respectively at different grid points before sowing and after the harvesting was more than t_{cri} value [1.699]. This meant that there was significant difference in the mean exchangeable sodium percentage values of the soil samples drawn before sowing and after harvesting. The reduction in ESP was due to the SSD system, which helped in leaching of salts. However, the reduction was not considerable without the application of gypsum as it was to needed to be applied to tackle the sodicity conditions. With application of the gypsum in the following season[s], it is expected that the reclamation process would be complete by significant reduction in ESP. These results were in agreement with that of the studies, which revealed that the ESP reduced after the implementation of the subsurface drainage system [8,11].

Land Improvement and Crop Performance Studies

It was observed that out of 10.65 ha land, earlier only 2.10 ha was utilized for the purpose of cultivation due to perpetual water logging and salinity problems caused by unscientific practices of land and water after the advent of irrigation. However, as a result of the drainage work, the land conditions improved. After the installation of the SSD system, the cropped area increased from 2.10 to 4.03 ha. The post-drainage yield also increased to 62.00 q ha-1 as compared to pre-drainage yield of 41.00 q ha-1, which meant an increase of 51.21 per cent. Increase in grain yield due to subsurface drainage was reported in previous studies [3, 4, 12-14].

Conclusions

based on the observation and analysis of the soils samples collected before sowing and after harvesting it could to observed that the ECe, $Ca^{2+}+Mg^{2+}$ and Na^+ content was found to be reduced significantly as compared to pre-sowing conditions but the soil reaction and K^+ was found to be increased due to increase in sodicity of the soil and higher application of fertilizers. finally ESP was observed to be reduced in smaller amount as compared to pre sowing conditions, as the soil was found to be sodic in nature, there is need of application of gypsum in requires amount in order to turn the soil from sodicity to saline or non saline soils. The crop yield was observed to be increased by 51.21 per cent as compare to pre drainage conditions.

Conflict of Interest: None declared

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