Assessment of Spent-Wash Application on Soil Characteristics and Wheat Growth Dynamics

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Abstract

This study evaluated the effectiveness of combining a spent wash with chemical fertilizers. Wheat (TJ-83) was cultivated, and distillery spent wash was applied for irrigation at 0% (100% canal water with chemical fertilizer), 10%, 20%, and 30% dilution. The parameters of soil and spent wash pH, EC, S, N, P, K, Ca, Mg and Na, COD, BOD, TDS, TSS, pH, EC, N, P, K, Ca, and Mg were analyzed. Analysis results indicated the significant effects of a spent wash concentration on soil properties. Maximum soil pH (8.0) and N (0.92%) were recorded at 30% concentration, along with the highest Ca (32.5 mg/kg), EC (0.015S/m, and SAR (0.22). Maximum P (4.36 mg/kg) and K (180 mg/kg) were noted at 20% concentration, with the lowest Na (20 mg/kg) and S (2.72 mg/kg). Mg (60 mg/kg) was highest at 10% concentration. Variance analysis showed significant effects of soil depth post-harvest. Maximum pH (8.0), P (4.36 mg/kg, and Ca (15 mg/kg) were at 12 inches depth, while maximum K (180 mg/kg), Mg (60 mg/kg), Na (45 mg/kg), and S (34.42 mg/kg) were at 6 inches depth. The concentration of spent wash had a significant impact on wheat growth parameters, with the tallest plant height reaching (72 cm), tillers (308), grain weight per spike (1.373 g), and grains per spike (79) at 30% concentration.

Keywords: Spent wash, Soil Properties, Wheat Growth, Soil fertility, Wastewater management

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Introduction

Distillery spent wash (DSW) is a liquid byproduct generated by the sugarcane industry, containing a significant amount of both organic and inorganic substances. It is rich in macronutrients such as nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S), as well as micronutrients like zinc (Zn), copper (Cu), iron (Fe), and manganese (Mn). These nutrients contribute to the enhancement of crop growth and yield. When applied in optimized doses, DSW improves soil enzymatic and microbial activity, increases organic carbon content, boosts nutrient uptake, enhances soil porosity, water retention, and aggregate stability, and strengthens antioxidant activities. As a result, it improves photosynthetic efficiency, growth, and yield by Umair et al., (2021).

Managing waste has become one of the biggest global challenges today. With rapid industrialization, the volume of wastewater has grown significantly, making it both challenging and costly to manage. The composition of wastewater varies widely depending on the industry it comes from. Recently, there has been growing interest among agriculturalists and environmentalists in using wastewater for agriculture. This is because wastewater not only helps meet the nutritional needs of crops but also offers the added advantage of improving soil health and boosting crop yields by Kuntal et al., (2004).

The sugarcane industry is one of the leading agro-based sectors, playing a significant role in the socio-economic development of many countries. This industry focuses on processing sugarcane to produce sugar, contributing both to local economies and global markets by Poddar et al., (2017).

The spent wash has been recognized with high COD and BOD value which is very dangerous to be discarded on land and stream water. It can also be a good source of renewable energy due to its high organic load. It doesn't contain any toxic metals that are why it was used as a substitute for irrigation water. It has high number of micronutrients along with Sulphur, potassium, phosphorous and nitrogen contents. Its application on agricultural lands has been regarded as environmentally friendly and it is also found best for soil fertility maintenance if given as irrigation water substitute by Ahmed et al., (2016).

The natural water has been used by farmers due to insufficiency of water supply due to which high amount of salt residues in ground water affects agricultural land. Since the waste treatment methods which are used conventionally to treat wastewater and use of fertilizers are too much costly for farmers hence alternative methods like distillery effluents are taking much more attention by Kumar et al., (2018).

The objectives of the studies are as follows:

i. To determine the Physico-chemical properties of spent wash obtained from Metol distillery Matiari sugar mill
ii. To determine the impact of spent wash on soil properties and wheat growth.
iii. To compare the efficiency of spent wash with chemical fertilizers for wheat crop.

Materials and Methods

Experimental Site

The present study was conducted on Latif form at Sindh Agriculture university, Tando Jam. Latitude: 25° 25' 21.40" N, Longitude: 68° 32' 13.38" E, Sindh, Pakistan.

Spent wash Sampling.

A sample of spent wash was taken from Metol distillery Matiari sugar mill and examined for its physicochemical parameters (BOD, COD, TDS, TSS, EC, pH, P, N, K, Ca, and Mg). The wasted wash is combined with water in various proportions and then used to irrigate wheat crops. The spent wash fraction is set to 10%, 20%, and 30% of irrigation canal water. The spent wash was delivered in a lid bottle (1.5liter) for analysis of its physicochemical qualities, and it was gathered in a 500-liter cane for irrigation. The percentage assimilation of spent wash was 10, 20, and 30%, with 90, 80, and 70% canal water

Two 500-liter drums were obtained, with each treatment requiring around 20 liters of canal water. 10, 20, and 30% of 380 liters will result in 38, 76, and 114 liters of squandered wash, respectively. The spent wash, mixed with canal water in a drum, was then applied to the land. This way, the wheat crop was irrigated three to four times.

Soil Sampling

Samples of soil were collected at the depth of 6", 12" and 18" (three replications) with the help of auger and stored in the plastic bags and brought to the Nuclear Institute of Agriculture (N.I.A) laboratory, Tando jam, Pakistan.

Wheat Growth Parameters

The plant growth parameters plant height(cm), tillers (m^2), weight of grains per spike, number of grains per spike, grain yield (Kg ha^{-1}) seed index (1000 seed weight g), biological yield (kg ha^{-1}) was observed during the experiment.

Experimental arrangement

T_1 = Traditional (100% canal water with chemical fertilizer)

T_2 = 10% spent wash + 90% canal water

T_3 = 20% spent wash + 80% canal water

T_4 = 30% spent wash + 70% canal water

Experimental Treatments

The total area of the experimental plot was (12x4) = $48m^2$ and each treatment was covered (2x2) = $4m^2$ in this way twelve treatments was made with three replications and in each replication four treatment was installed and one was the control treatment.

Physicochemical Properties of Soil and Spent Wash

Electrical conductivity of spent wash and soil was determined with the help of a portable conductivity meter (Hana Model-8733, Germany) The pH of soil and spent Wash was analyzed with pH meter (Orion-ISE Model-SA-720 USA) The total nitrogen (%) in level in soil samples was determined by Kjeldahl's method as described by Jackson (1958b). The spectrophotometer of the Model Specord-200 PC Analytik Jen, Germany was used to analyze phosphorous via method of AB-DTPA and followed the procedure of Soltan pour and Schwab (1977). The flame photometer, model NumberPFP-7, Jenway UK was used for Potassium content via Method No. 11a, Pp.97.The Sodium content was obtained through Flame Photometer, model Number PFP-7, Jenway UK and the method used was 10a, Pp.96. The method of APHA (1995) was taken to check the TDS. The sample was filtered and evaporated. After evaporation the left-over residue was measured and resulted as total dissolved solids. It is the measurement of the capacity of the organic matter to consume highest amount of oxygen in the given sample for completing the oxidation. The method of complex metric titration was used to determine Mg and Ca content by using EDTA (ethylene di-amine tetra acetic acid). The sample containing Na/K when sprayed into the flame produces a characteristic light as result of electrons excitation. The concentration of Na/K is then determined via the intensity of radiation. To read their concentration a suitable optical device is used at 529/768mm (Tondon 1998).

Agronomical Parameters of Wheat Crop

The height of the plant was measured using a measuring tape, from the base of the plant to the tip of the spikes. Number of tillers plant (m^{-2}) also counted for tillers by selecting random plants and average was calculated. Number of grains ($spike^{-1}$) was also noted by selecting random plants of the mature crop and the average was obtained, Weight of grains $spike^{-1}$ (g) was by collecting the grains from random spikes of the mature plants and their weight was taken in grams and the mean average value was noted. The seed index was calculated by collecting 1000 grains from each plot and their weight was measured. The weight of collected grains and foliage were weighed and calculated as biological yield (ha^{-1}) in Kilograms. The grains were received from each treatment and weighed, based on grain yield ha^{-1} was weighed in kilograms.

Results

Soil Analyzing

The soil analyzed at different depths, the maximum value of pH (8.2), K (128mg/kg), Mg (4.5 mg/kg), Na (1.73 mg/kg), S (32.4 mg/kg) and EC (0.34S/m) of soil were recorded at 6-inch soil depth. Whereas the N (0.36 %), P (4.46 mg/kg) and Ca (1.875 mg/kg) were higher in soil sample taken from 12-inch soil depth. The value of SAR (1.13) was observed maximum in soil sample taken from18 inch soil depth.

Spent wash analyzing at different concentrations in canal water

The maximum value of TDS (12576mg/l), N (0.09%), P (0.026mg/l), K (4800 mg/l), Ca (90 mg/l), Mg (29.5 mg/l), Na (450 mg/l) and EC (19.65S/m) were recorded at 30% concentration of spent wash. Whereas the highest pH (7.7) at 30%, COD (4500mg/l) and BOD (18000mg/l) of spent wash were recorded at 0% (100% canal water with chemical fertilizer) of spent wash.

Irrigation scheduling for wheat crop (per Irrigation)

The four irrigation treatments, a total of 1520 Liters of canal water were applied. In the first treatment, only canal water was used 380 Liters with no spent wash added. For the second treatment, 10% of the water was replaced with 38 Liters of spent wash, leaving 342 Liters of canal water in the mix. In the third treatment, the spent wash content increased to 20%, with 76 Liters of spent wash mixed into 304 Liters of canal water.

Soil pH

The maximum pH of 8.0 was recorded at 6 inches soil depth with spent wash application 10%, 20% and 30%. The minimum pH of soil i-e 7.7 observed at 12 inches soil depth with 0 % (100% canal water with chemical fertilizer) spent wash.

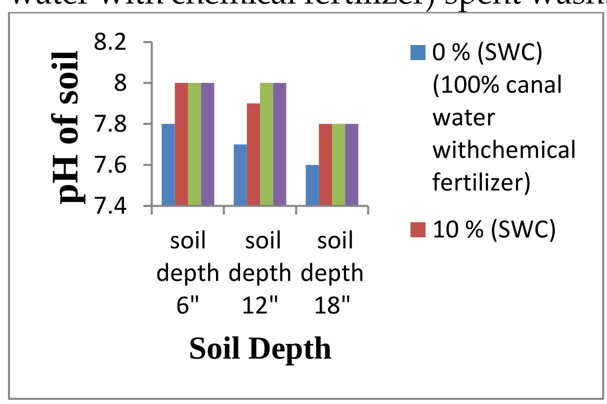

Figure 1 Effect of soil depth and spent wash concentration on pH of soil

Nitrogen (N %)

The maximum value of N 0.92% was recorded at 18 inches soil depth with spent wash application 30%. The minimum value of N in soil i-e 0.06% observed at 18 inches soil depth with 0%(100% canal water with chemical fertilizer) spent wash.

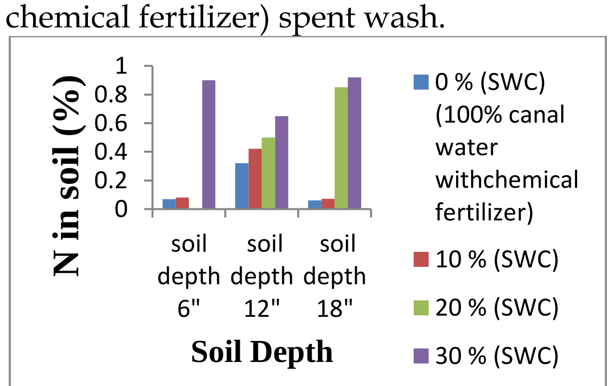

Figure 2 Effect of soil depth and spent wash concentration on N of soil

Phosphorus (P mg/kg)

The maximum value of P 4.36 mg/kg was recorded at 12 inches soil depth with spent wash application 20%. The minimum value of P in soil i-e 0.976 mg/kg observed at 6 inches soil depth with 0%(100% canal water with chemical fertilizer) spent wash.

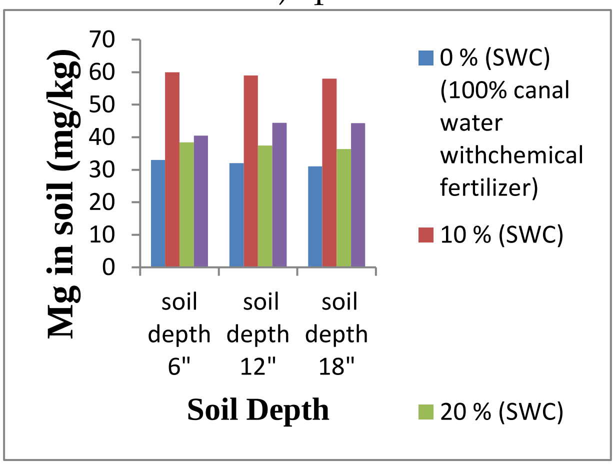

Figure 3 Effect of soil depth and spent wash concentration on P of soil

Calcium (Ca mg/kg)

The maximum value of Ca 50 mg/kg was recorded at 12 inches soil depth with spent wash application 0%(100% canal water with chemical fertilizer). The minimum value of Ca in soil i-e 32.5 mg/kg observed at 6 inches soil depth with 30% spent wash.

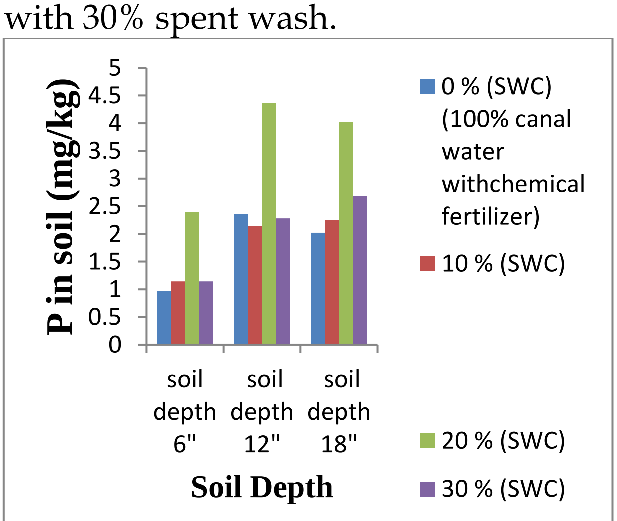

Figure 4 Effect of soil depth and spent wash concentration on Ca of soil

Electrical Conductivity (EC S/m)

The maximum value of EC 0.365 S/m was recorded at 6 inches soil depth with spent wash application 0% (100% canal water with chemical fertilizer). The minimum value of EC in soil i-e 0.15 S/m observed at 18-inch soil depth with 30% spent wash.

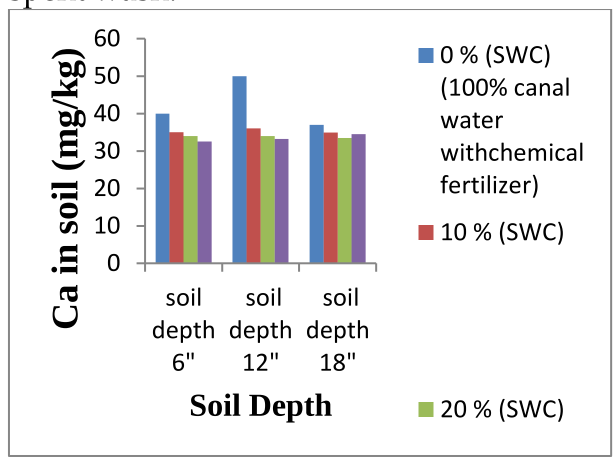

Figure 5 Effect of soil depth and spent wash concentration on EC of soil

Magnesium (Mg mg/kg)

The maximum value of Mg 60 mg/kg was recorded at 6 inches soil depth with spent wash application 10%. The minimum value of Mg in soil i-e 31 mg/kg observed at 18 inches soil depth with 0% (100% canal water with chemical fertilizer) spent wash.

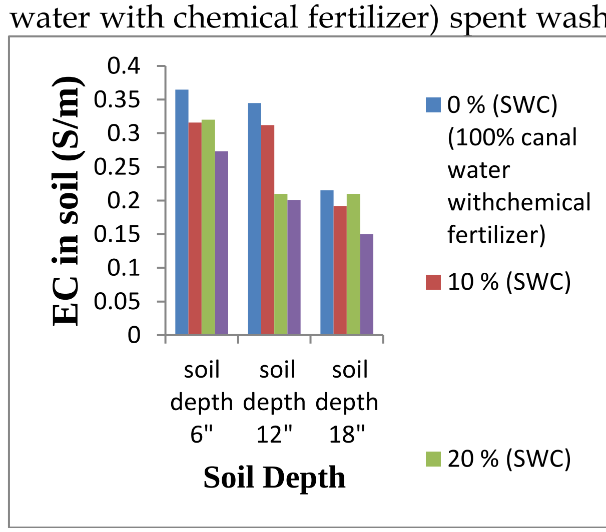

Figure 6 Effect of soil depth and spent wash concentration on Mg of soil

Plant height (cm)

The highest value of plant height 72 cm was observed at 30% of spent wash concentration. However, the lowest plant height 61.83 cm was recorded at 0 % (100% canal water with chemical fertilizer) spent wash concentration.

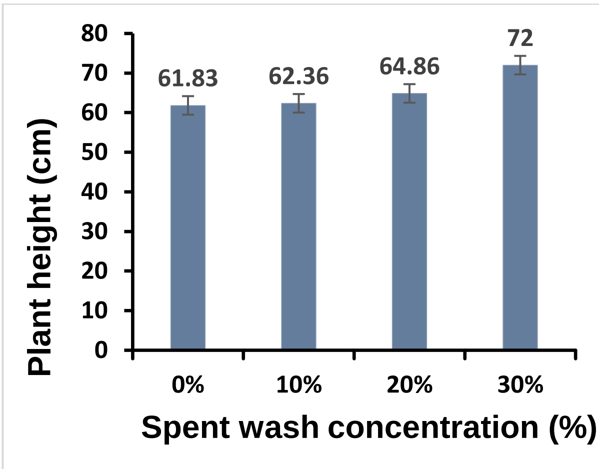

Figure 7 Plant height (cm) under the effect of different spent wash concentration

Number of Tillers m^{-2}

The highest value of number of tillers 308 was observed at 30% of spent wash concentration. However, the lowest number of tillers 252 was recorded at 0%(100% canal water with chemical fertilizer) spent wash concentration

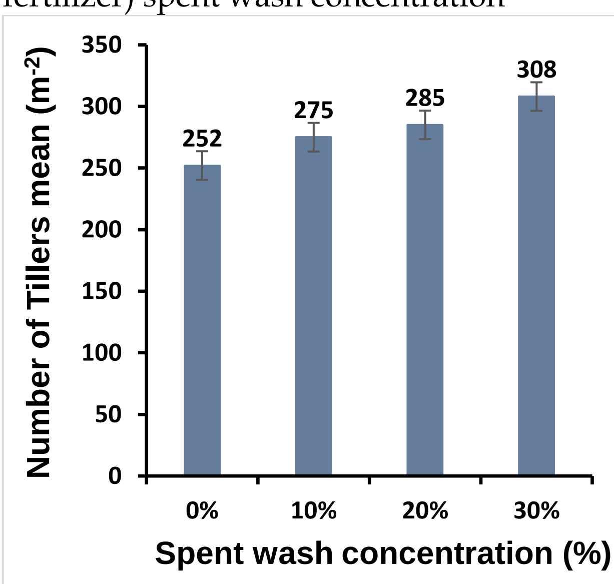

Figure 8 Number of tillers m^{-2} under the effect of different spent wash concentration

Biological Yield (kg ha^{-1})

The highest value of biological yield was 35666.66 kg ha^{-1}observed at 30% of spent wash concentration. However, the lowest biological yield 19000 kg ha^{-1} was recorded at 0% (100% canal water with chemical fertilizer) spent wash concentration

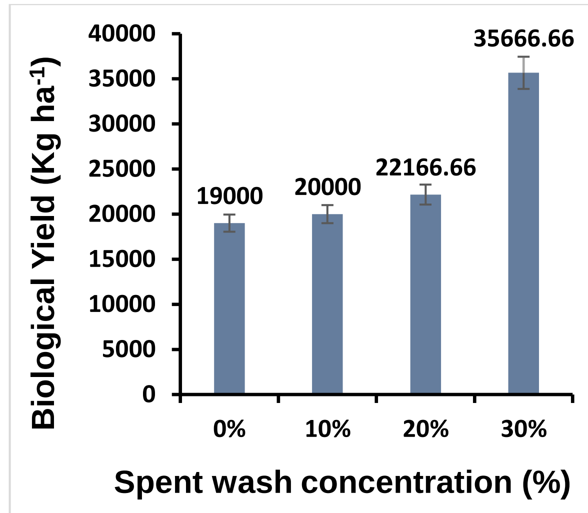

Figure 9 Biological yield (Kg/ha) under the effect of different spent wash concentration

Weight of grain per spike (g)

The highest value of weight of grain per spike 1.373 g observed at 30% of spent wash concentration. However, the lowest weight of grain per spike 0.75 g was recorded at 0%(100% canal water with chemical fertilizer) spent wash concentration (Fig.15)

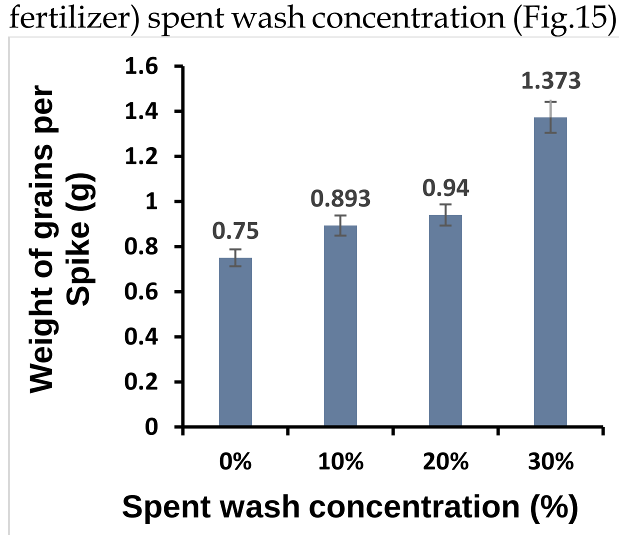

Figure 10 Weight of grain (g) per spike under the effect of different spent wash concentration

Number of Grains per spike

The highest number of grains per spike 79 observed at 30% of spent wash concentration. However, the lowest number of grains per spike 42.33 was recorded at 0% (100% canal water with chemical fertilizer) spent wash concentration.

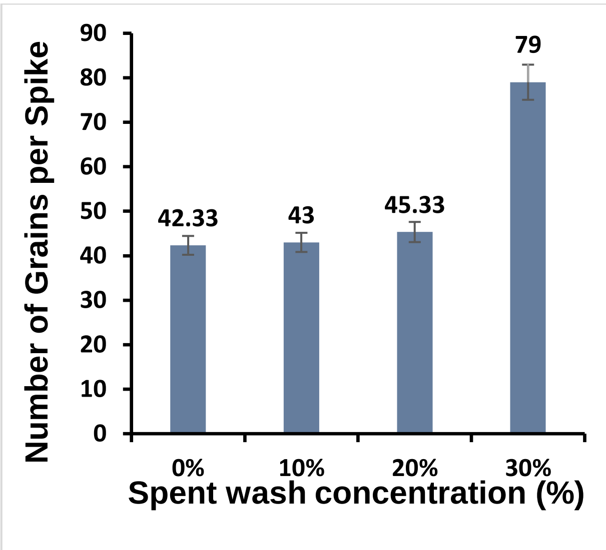

Figure 11 Number of grains per spike under the effect of different spent wash concentration

Seed Index (g)

The highest value of seed Index 24.33 g observed at 30% of spent wash concentration. However, the lowest seed Index 18 g was recorded at 0% (100% canal water with chemical fertilizer) spent wash concentration.

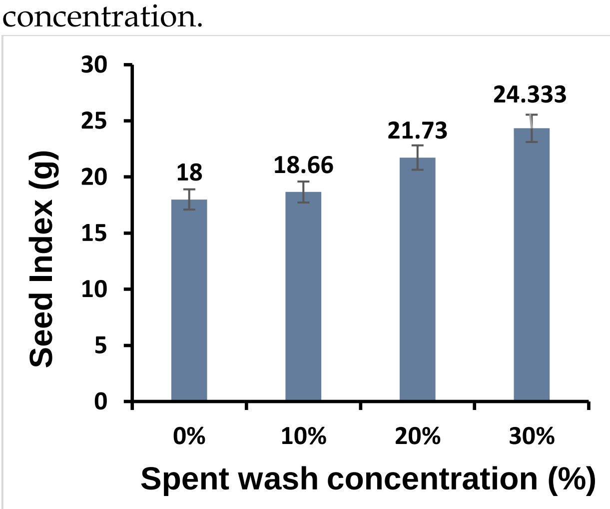

Figure 12 Seed Index (weight of 1000 seeds in "g") under the effect of different spent wash concentration

Grain Yield (kg/ha)

The highest grain yield 7016.66 kg/ha observed at 30% of spent wash concentration. However, the lowest grain yield 3600.33 kg/ha was recorded at 0% spent wash concentration.

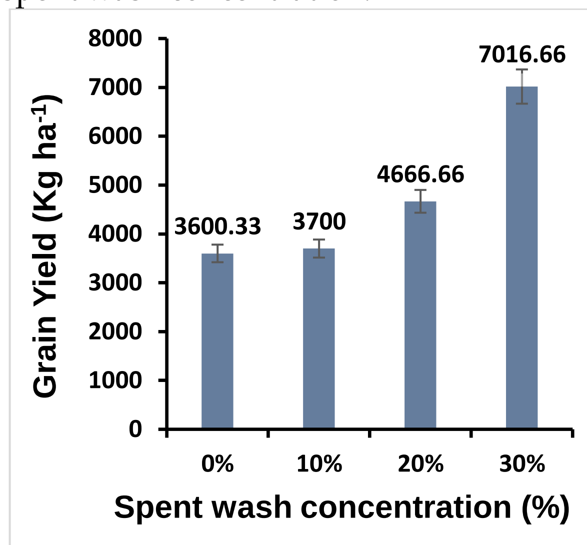

Figure 13 Grain yield (Kg/ha) under the effect of spent wash concentration

Discussion

The findings of the study indicated that the effects of spent wash on soil characteristics was the soil pH slightly increased by increasing the spent wash concentration and decreases in soil depth. The N, P and K significantly influenced by the spent wash concentration which are essential nutrients for the fertility of soil and plant growth. Whereas the Mg, Na, SAR severe decreased by increase in depth and all components increase if the rate of spent wash increases. The impact of spent wash on plant growth parameters, Seed index (1000 seed weight g), Tillers (m^{-2}), Biological yield (kg ha^{-1}), Plant height (cm), Weight of grains per spike, Number of grains per spike, and Grain yield (Kg ha^{-1}) indicated significant. The current results are consolidating is agreement with many previous investigators. Somawanshi and

Yadav (1992) concluded that additions of diluted spent wash would not add soluble salts to the soil provided adequate discharge of soil solution. Pathak *et al*., (1999) indicated that physicochemical properties of the soil in such some way that it reduces particularly exchangeable atomic number 11 share by 55.96 %, electrical physical phenomenon by 16.36 %, exchangeable atomic number 11 by nine 61 try to pH of the soil by 17.24% over four weeks of the treatment, reflective its potential as associate degree economical eco-friendly soil change for sodic soil. Ramana *et al*., (2002) investigated to check the effluent of various concentrations (0, 5, 10, 15, 20, 25, 50, 75 and 100%) of effluent (spent wash) on seed germination (%), speed of germination in some vegetable crops, the works effluent didn't highlighted any restrictive effects on seed growth. Bolan and Mahimairaja (2004) explained that the dosage of spent wash greater than 250 m^3 ha^{-1} was found harmful to the soil fertility and growth of crop. However, when the dosages were reduced to 125 m^3 ha^{-1} had tremendous improving effects on germination and yield of crops grown on dry lands. The organic matters like bio composite, leaf and farmyard manure when used in combination with spent wash were also found good for dryland crops. It was noted that sodic soils with high pH when treated with spent wash were found with high soluble salts mainly sodium (Na) on surface of the land. Diaganet al., (2008) concluded that the impacts of spent wash on agriculture and on the ground water quality. It was observed that the germination percentage of agricultural crops decrease with the concentration of spent wash and determined severe bad effect on livestock health, farmer's health and soil fertility. It has also depleted the groundwater quality. Chidankumaret al., (2009) evaluated the variation of soil fertility by the application of different proportions of spent wash. Spent wash with 50 and 33% applied to the soil. The experimental soil was analyzed for its physicochemical properties. Spent wash treated soil fertility were again analyzed and it was noted that the fertility increased in the order 33%>50%>SW treated soil. Jadhava et al., (2009) revealed that the impact of various diluted spent wash at 0, 25, 50, 75 and 100% on seed germination and germination of selected crops as wheat (Triticum aestivum), hickpea (Cicer arietinum) and fenugreek. Germination percentage decreased with increasing concentration of spent wash in the selected crops, whereas the germination speed, germination rate increased from control to 25 and 50% concentration and decreased from 50 to 75% and 100% effluent. Sukanya et al., (2010) reported that the higher yield (52.59 q ha^{-1}) of wheat crop was rate at 1:50 SW dilution due to greater uptake of nutrients ratio compared to other dilution ratios. Due to greater nutrient uptake the biomass levels and economic yield was also recorded higher. It was therefore observed that at 1:50 the yield was higher, but less residues nutrient availability was recorded due to higher nutrient uptake by crop. However, the crop treated with less dilution levels resulted in higher residual nutrients availability.

Chandraju and Chidankumar (2010) concluded that the growth and yield of forages; Anjan Grass, Setaria Grass, Para Grass, and Rhodes grass irrigated with spent wash of different ratios. The mineral contents like potassium, phosphorus and nitrogen along with chemical and physical characteristics were analyzed in experimental soil after using three ratios of spent wash (1:1, 1:2, and 1:3). About 3 inches of all the grass were sown in the separate pots and irrigated with different spent wash ratios along with raw water. It was concluded that spent wash along with raw water can be used for irrigation purpose to achieve good results in terms of growth and yield and it is also an environmentally friendly practice because it does not have any side effects to environment, water and soils. Bhukya (2007) concluded that spent wash had a favorable effect on pH, EC, nutrients. Kalaiselvi and Mahimairaja (2010) investigated that the spent wash treated soil is enriched with plant nutrients such as N, P and K. Chandraju et al., (2010) concluded that diluted spent wash can be expediently used for cultivation of crops.

Conclusions

The result revealed that the application of diluted spent wash had a significant impact on soil properties. In soils treated with spent wash, the highest pH and nitrogen (N) levels were recorded at a 30% spent wash concentration. On the other hand, sodium adsorption ratio (SAR), electrical conductivity (EC), and calcium (Ca) were at their highest in untreated soil (0% spent wash). Interestingly, potassium (K) and phosphorus (P) peaked at 20% spent wash concentration, accompanied by the lowest levels of sodium (Na) and sulfur (S). Meanwhile, magnesium (Mg) reached its maximum at a 10% concentration. The analysis of variance also showed that soil depth significantly affected soil properties after wheat harvesting. Soil samples from a depth of 12 inches had the highest levels of pH, phosphorus (P), and calcium (Ca), while nitrogen (N) and SAR were at their lowest. Conversely, samples from 6 inches depth showed the highest levels of potassium (K), magnesium (Mg), sodium (Na), and sulfur (S). The spent wash concentration also had a significant effect on the agronomic performance of the wheat crop. Wheat grown with 30% spent wash concentration showed the tallest plants, the highest number of tillers, the heaviest grain weight per spike, and the largest number of grains per spike. This was followed by crops treated with 10% spent wash, with the lowest values observed at 20%. However, when it came to biological yield, seed index, and overall grain yield, the best results were achieved with 30% spent wash, followed by 20% and 10% concentrations. When compared the efficiency of spent wash to chemical fertilizers, spent wash consistently outperformed chemical fertilizers in terms of both plant and soil parameters. Wheat plots treated with spent wash had greater plant height, more tillers, heavier grains per spike, higher grain counts, and improved biological and grain yields. Similarly, soil properties such as pH, EC, sulfur, nitrogen, phosphorus, potassium, calcium, magnesium, and sodium were more favorable in spent wash-treated plots than in those treated with chemical fertilizers.

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