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A COMPARATIVE STUDY OF DISTILLERY SPENT WASH WITH NPK (STANDARD CHEMICAL FERTILIZERS) AT SEEDLING STAGE OF SORGHUM (*SORGHUM BICOLOR L.*)

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Abstract

The price of commercial chemical fertilizers is beyond the purchasing power of farming community of world's developing countries. Therefore, to find out the substitute of these commercial chemical fertilizers a comparative study was conducted at seedling stage of sorghum variety named Sarokartuho in seed testing laboratory. The experiment was carried out in completely randomized design (CRD) with three replications and three treatments, i.e. only drinking water (as check), recommended dose of Nitrogen, Phosphorus, Potassium (NPK commercial fertilizer), 30%+70% of distillery spent wash + water, 50%+50% distillery spent wash + water respectively. The results for spent wash (T_2) were at seed germination% (95.33%), shoot length (6.62 cm), root length (5.49 cm), shoot fresh weight (0.18 mg), root fresh weight (0.019 mg), shoot dry weight (0.017 mg) and root-dry weight (0.005 mg) of sorghum. However, the maximum values for these all traits of observations except seed germination were recorded at recommended dose of NPK (chemical fertilizers).

Keywords: Distillery spent wash, sorghum, root, shoot, NPK

1. INTRODUCTION

In South Asia, Africa, and Central America sorghum is cultivated for grain purpose. It is a major food crop in that region of the world. In USA, Australia and South America, sorghum is also cultivated mostly as a fodder crop. Sorghum is adapted to warm and dry climate but the greatest area of the crop is cultivated in drought-prone areas of the world. In these areas, sorghum is usually grown with limited inputs in conditions of sparse rainfall and low soil fertility. Therefore, it faces disease and pest problems, which results low yields (Purnima, 2009).

Sugarcane is an important cash crop of Pakistan. It is mainly grown for manufacturing the sugar and sugar-related products. It also produces essential items for industries like molasses, chipboard and paper. Its shares in value added of agriculture and GDP are 3.4 percent and 0.7 percent, respectively (Bayer Crop Science, 2014). Apart from the sugar and alcohol, sugar mills generate many by-products and waste materials. Distillery spent wash is the unwanted residual liquid waste generated during alcohol production (Sarayu *et al.*, 2009). The spent wash is acidic (pH 3.94 to

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4.30) and loaded with organic and inorganic salts, resulting in high EC (30-45 dS/m). As it is a plant originated, hence it also contains considerable amount of plant nutrients and organic matter (Table 1). As spent wash contains essential plant-nutrients, so, it can effectively be used as a source of plant nutrients and as soil amendment. Recently, the presence of appreciable amounts of plant growth promoter viz., gibberellic acid (GA) and indole acetic acid (IAA) have also been detected from spent wash which further enhances the nutrition value of spent wash. Distillery spent wash contains some soluble salts and essential plant nutrients. Among the plant nutrients, potassium (K) is found in higher amounts followed by nitrogen (N) and phosphorus (P). The presence of calcium (Ca) in considerable amounts makes the spent wash a potential amendment for reclaiming the sodic soils. (Murugaragavan, 2002). The high concentration of Ca (2050 – 7000 mg/l) in spent wash may have the potential in reclaiming the sodic soils similar to that of gypsum‘s function (Santiago *and* Nanthi, 2004).

The effects could be ascribed to the nutrients and the growth promoters like gibberellic acid (GA) and indole acetic acid (IAA) present in the spent wash. The presence of appreciable amounts of plant growth promoter such as GA and IAA add an additional value to the spent wash. It was observed that the activity of enzymes and microbes was also enhanced in soils amended with the spent wash. (Santiago *and* Nanthi, 2004).

Sorghum (*Sorghum bicolor*) ranks as a one of the major crop of the world next to wheat and rice. It is extensively cultivated in Africa, Argentina, Australia, Central and South America, China and India. It is tolerant crop to heat and drought. However, sorghum cannot tolerate low temperature. If it is exposed to temperature below 5 ^{o}C prussic acid accumulates in its vegetation and may reach levels that are toxic to livestock. However, in Sindh this crop is harvested well before onset of low temperature (Bhatti and Atta, 1996). As far as spent wash is concerned, technologies based on scientific experimentation are needed for effectively utilizing this valuable resource in agriculture without any environmental hazards (Santiago and Nanthi, 2004).

Table 1: Some important properties of spent wash are shown in the following table

pH	3.9 – 4.3
EC (dS/m)	30.5 – 45.2
Biological Oxygen demand	46100 – 96000
Chemical oxygen demand	104000 – 134400
Total dissolved solids	79000 – 87990
Nitrogen	1660 – 4200
Phosphorous	225 – 3038
Potassium	9600 – 17475
Calcium	2050 – 7000
Magnesium	1715 – 2100
Sodium	492 – 670
Sulphate	3240 – 3425
Chloride	7238 – 42096
Zinc	3.5 – 10.4
Copper	0.4 – 2.1
Manganese	4.6 – 5.1
Gibberellic acid	3246 – 4943
Indole acetic acid	25 – 61

(All values are in mg/l unless otherwise stated)

Sources: Rajukkannu and Manickam (1997); Valliappan (1998); Murugaragavan (2002)

Therefore a careful study has been conducted to examine the utilization of distillery spent wash (DSW) as an alternate source of fertilizer for crop plants in order to assess the impact of DSW on germination and early growth stages of sorghum (*Sorghum bicolor L.*) and to compare the efficiency of NPK fertilizers with DSW as a source of plant nutrients.

2. MATERIALS AND METHODS

A pot experiment was conducted at "Seed Testing Laboratory", Department of Agronomy Sindh Agriculture University Tandojam, Pakistan. The seed of variety named Sarokartuho of sorghum (*Sorghum bicolor L.*) was received from Agriculture Research Institute Tandojam, Pakistan and distillery spent wash was received from Unicol Ltd. at (Mirpur Khas Sugar Mills Ltd.), Sindh, Pakistan. The seed was soaked with water for 24 hours before sowing. Then ten good seeds with uniform size were sown in each sand-filled pot. Ten pots were used for each replication. Total three treatments were applied, which were, T_1= the proposed dose of NPK was applied at the rate of 120-50-50 kg per acre respectively in NPK treated pots, T_2= spent wash with prepared concentrations of 30%+70% (distillery spent wash + water) and T_3= 50%+50 (distillery spent wash + water) was applied in DSW treated pots respectively. The experiment was carried out in Completely Randomized Design (CRD) with three replications. Then the data was collected for germination % 10 days after sowing (DAS) and other early growth traits were recorded 25 days after sowing (DAS) such as, shoot-root length (cm), shoot-root fresh weight (mg) and shoot-root dry weight (mg).

3. RESULTS

3.1. Seed germination (%)

The results for seed germination% of sorghum as affected by proposed dose of NPK and different spent wash concentrations presented in table 2.

The table showed maximum seed germination % 95.33 with application of T_2 distillery spent wash + water followed by T_1 at 92.67%. However, T_3 spent + water (50+50) showed lowest germination% at 78.67. The non-fertilized (control as check) plants (control as check) produced better on seed germination at 83% which was better than T_3.

Table 2: NPK and spent wash effects on germination (%) of sorghum (*Sorghum bicolor L.*) 10 days after seed sowing

Treatments	Germination %	
Non fertilized plants (Control as a check)	83.00	D
T_1 = NPK treated plants	92.67	A
T_2 = Spent wash + water = 30%+70%	95.33	B
T_3 = Spent wash + water = 50% + 50%	78.67	C

Control as check = Non-treated plants.
T_1 = Traetment1, T_2 = Treatment 2 & T_3 = Treatment 3
A, B, C, D = Ranking (Grading) of seed germination according to its percentage

3.2. Shoot length (cm)

The results for shoot length (cm) of sorghum as affected by NPK and different concentrations of spent wash are presented in table 3.

The result showed that the maximum shoot length at 8.37 cm was obtained with NPK application followed by distillery spent was + water (T_2) at 6.62 cm was observed. While T_3 produced 5.14 (cm) of shoot length. Furthermore, results indicated that non-fertilized plants had adverse effects on shoot length which was found at 4.11 (cm).

Table 3: NPK and spent wash effects on shoot length (cm) of sorghum (*Sorghum bicolor L.*) 25 days after seed sowing: The minimum root length was recorded of the plants under control as check at 4.11 cm.

Table 3: NPK and spent wash effects on shoot length (cm) of sorghum (*Sorghum bicolor L.*) 25 days after seed sowing

Treatments	Shoot length (cm) (average)
Non fertilized plants (Control as a check)	4.11 D
T_1 = NPK treated plants	8.37 A
T_2 = Spent wash + water = (30%+70%)	6.62 B
T_3 = Spent wash + water = (50% + 50%)	5.14 C

cm = centimeter

Full forms of other abbreviations are as same as for table 2

Ranking is as same as for above tables

3.3. Root length (cm)

The results for root length (cm) of sorghum as affected by different seed priming sources presented in table 4.

The table showed that T_1 caused maximum root length at 6.25 (cm) followed by 5.49 cm which was observed by the application of T_2. However, T_3 showed 4.16 root lengths. Whereas, further results indicated that control as a check produced minimum root length recorded at 3.19 cm.

Table 4: NPK and spent wash effects on root length (cm) of sorghum (*Sorghum bicolor L.*) 25 days after seed sowing

Treatments	Root length (cm)
Non fertilized plants (Control as a check)	3.19 D
T_1 = NPK treated plants	6.25 A
T_2 = Spent wash + water = (30%+70%)	5.49 B
T_3 = Spent wash + water = (50% + 50%)	4.16 C

All abbreviations are as same as in table 3

3.4. Shoot fresh weight (mg)

The results for shoot fresh weight (mg) of sorghum as affected by NPK and different spent wash concentrations are presented in table 5.

The results showed that the maximum shoot fresh weight was recorded from plants under T_1 at the average of 0.23 gm followed by T_2 at 0.18 mg. However, T3 resulted higher shoot fresh weight at 0.12 mg than control as check which was at 0.10 mg.

Table 5: NPK and spent wash effects on shoot fresh weight (mg) of sorghum (*Sorghum bicolor L.*) 25 days after seed sowing

Treatments	Shoot fresh weight (mg) (average)
Non fertilized plants (Control as a check)	0.10 D
T_1 = NPK treated plants	0.23 A
T_2 = Spent wash + water = (30%+70%)	0.18 B
T_3 = Spent wash + water = (50% + 50%)	0.12 C

mg = milligram

all the data is presented as an average of all plants

all other abbreviations are as same as in table 3

3.5. Root fresh weight (mg)

The results for root fresh weight (mg) of sorghum as affected by NPK and different spent wash concentrations are presented in table 6.

The results showed that the T_1 produced maximum root fresh weight at the average of 0.026 mg followed by T2 which resulted 0.19 mg. However, T3 showed the root fresh weight at 0.013 mg which was higher than control as check which was at 0.010 mg.

Table 6: NPK and spent wash effects on root fresh weight (mg) of sorghum (*Sorghum bicolor L.*) 25 days after seed sowing

Treatments	Root fresh weight (mg) (average)
Non fertilized plants (Control as a check)	0.010 D
T_1 = NPK treated plants	0.026 A
T_2 = Spent wash + water = (30%+70%)	0.019 B
T_3 = Spent wash + water = (50% + 50%)	0.013 C

All abbreviations and rule for ranking are as same as for above table

3.6. Shoot dry weight (mg)

The results for shoot dry weight (mg) of sorghum as affected by NPK and different spent wash concentrations are presented in table 7.

The results showed that the maximum shoot dry weight was recorded from application of T_3 which was at the average of 0.022 mg followed by T_2 at 0.017 mg. The results for T_3 application ranked 3^{rd} at 0.013mg. The minimum shoot dry weight was recorded from the control as check at 0.011 mg.

Table 7: NPK and spent wash effects on shoot dry weight (mg) of sorghum (*Sorghum bicolor L.*) 25 days after seed sowing

Treatments	Shoot dry weight (mg) (average)
Non fertilized plants (Control as a check)	0.011 B
T_1 = NPK treated plants	0.022 A
T_2 = Spent wash + water = (30%+70%)	0.017 C
T_3 = Spent wash + water = (50% + 50%)	0.013 D

All abbreviations and ranking of data are based on same rule as for above tables

3.7. Root dry weight (mg)

The results for root dry weight (mg) of sorghum as affected by NPK and different spent wash concentrations are presented in table 8.

The maximum average root dry weight was recorded for the application of T_1 at 0.005 mg followed by 0.003 mg from the T_2. However, (as per mathematical rule of conversion of digits after decimal), the control as check and T_3 showed ranking C at 0.001 mg.

Table 8: NPK and spent wash effects on root dry weight (mg) of sorghum (*Sorghum bicolor L.*) 25 days after seed sowing

Treatments	Root dry weight (mg)
Non fertilized plants (Control as a check)	0.001 C
T_1 = NPK treated plants	0.005 A
T_2 = Spent wash + water = (30%+70%)	0.003 B
T_3 = Spent wash + water = (50% + 50%)	0.001 C

All the abbreviations used in this table and ranking of results are as same as in above table 02

4. DISCUSSION

It is doubtless that day by day the prices of chemical fertilizers are increasing. As these chemical fertilizers are also used as the sources of major nutrients such as, NPK which are essential for the crop growth and development. And the fertilizers which contain NPK are widely used throughout the world of agriculture. So for this, a series of studies on comparative performance of different crop plants under proposed dose of NPK and different concentrations of spent wash has been started. This study is one of them. The general performance of sorghum for all measured traits of evaluation except seed germination under proposed dose of NPK is comparatively better than distillery spent wash. But it is very much important to note that when it was asked that “what were alcohol-mills doing with that spent wash?” The simple answer was “the alcohol manufacturing mills are discarding spent wash through drainage system of the areas and drain-out it to the nearest water-logged ponds”. As distillery spent wash contains about 13 essential elements (listed above in table 1) as well as gibberellic acids and indole acetic acid which play very much important and indispensable role in crop growth and development. In this study plants which received proposed dose of NPK performed best of all other conditions except seed germination percentage. It could be assumed that as pH of distillery spent wash was acetic, so, the germination% under T_2 was best of all other treatments and it was very poor at T_3 might be because of some toxic effects of high concentration of distillery spent wash + water at (50% + 50%). However, controlled plants (zero application of both NPK and distillery spent wash) showed predictably lowest values for all traits such as, germination%), shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight and root dry weight whereas, all other treated plants with NPK or spent wash had higher trends for all traits of measurement. These findings are in agreement with those of Mohamed Hussein and Ashok (2014), who also noted that the biomass of the plant which received NPK was higher than the plants which were not given NPK fertilizers. The crop growth and its attribute of sorghum improved under the positive impact of NPK application (Singh and Balyan, 2000). Not only in this study the performance of sorghum improved with proposed dose of NPK, but Sharma *et al.* (2000) also observed higher dry matter and more yield of wheat with the application of NPK than control. This better performance of sorghum under NPK application might be due to available forms of nitrogen, phosphorus and potassium, Shepherd and Withers (1999) has also agreed with this concept, which has extended the idea that sorghum is a heavy feeder of nutrients, particularly nitrogen uptake. Our findings for role of NPK in better performance of sorghum for all traits of measurement also resemble with that of Hasnabade *et al.* (1990) who observed that NPK application is beneficial for performance of soybean productivity. In case of distillery spent wash study, our recorded results were predictably higher than control as check and less than NPK treated plants. Radha (2011) has also recorded similar decreasing trends of traits under different concentrations of crude spent wash CSW (10, 100 ml kg^{1} soil) and distillery spent wash DSW (100 ml kg^{1} soil). In another study by Gahlot *et al.* (2011) observed that as the concentrations of spent wash increased from 2.5% to 20% so the root weight was decreased from 0.895 g $plant^{1}$ to 0.035 g $plant^{1}$ and at the same concentrations shoot dry weight also decreased from 0.668 g $plant^{1}$ to 0.441 g $plant^{1}$. These all studies suggest that as concentrations of distillery spent wash increased so, the performance of sorghum was comparatively poorer than recommended dose of NPK chemical fertilizers. Therefore, some more studies will be conducted on reduced concentrations of spent wash. In these upcoming studies the concentration of distillery spent wash would be used less than 30% with more than 70% of water. There is a great hope that after conducting upcoming studies on reduced concentration of distillery spent wash; we will be able to recommend the proper concentration of the distillery spent wash to the farmers as it could be utilized as a productive as well as cheapest substitute of chemical fertilizers.

5. CONCLUSION

It is concluded that the overall performance of sorghum crop at its seedling stage was best at the recommended dose of NPK while compared with all other treatments. However, the findings for response of sorghum to distillery spent wash + water at (30%+70%) has also opened a gate-way to utilize T_2 concentration of distillery spent wash with water in the areas where spent wash is easily available as compared to NPK chemical fertilizers. It was observed that as the concentration of DSW increased, so, the performance of crop decreased. Therefore, DSW at lower concentrations is only useful for getting good results from the crops under DSW treatment. Because of cost free availability of DSW, easiness and its convenience to bring this methodology in practice**, t**he farmers can apply this novel strategy for acquiring food sustainability at lower input cost.

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