Original Research Article

Effect of value added product from sugar industry on growth and yield attributes of maize

ABSTRACT

India is the major producer and consumer of sugar in the world. Molasses based distillery along with their product (alcohol) generate wastewater called as spent wash. The distillery spent wash can be utilized in agriculture as a source of potassic fertilizer. To investigate the impact of applying Value Added Product (VAP) from distillery spent wash as a potassic source on maize (*Zea mays* L.) crop, growth and yield parameters were compared with that of maize grown on Muriate of Potash (MOP) as a fertilizer source. For this study, the maize hybrid of COHM(8) was used and the field experiment was conducted at Agricultural College and Research Institute farm, Kudumiyanmalai, Pudukkottai, Tamil Nadu, India using Randomized Block Design with 3 replications. The treatments include absolute control (T1), 50% STCR-K through VAP (T2), 75% STCR-K through VAP (T3), 100% STCR-K through VAP (T4), 125% STCR-K through VAP (T5), 50% STCR-K through VAP + 50% STCR-K through inorganic fertilizers (T6) (MOP) and 100% STCR-K through inorganic fertilizer (MOP) (T7). As a result, 125 % STCR-K as VAP produced better growth and yield characteristic, it was on par with 100 percent STCR-K as VAP and followed by 75 percent STCR-K as VAP when compared to control (T_1). It is concluded that application of VAP from distillery spent wash (DSW) resulted in increased nutrient status of soil which in turn increased higher growth and yield parameters of maize.

Keywords: ***Value added product, distillery spent wash, Molasses, Growth and yield attribute, Maize***

1. INTRODUCTION

Maize (*Zea mays* L.) is one of the important cereal crops next to wheat and rice in the world. In India, it ranks fourth position after rice, wheat and sorghum. It accounts for approximately 9 per cent of total food grain production in the country, contributing about 2 per cent of the world maize production. It has higher productive potential compared to any other cereal crops hence, it is called as "king of cereals" (Adiveppa *et al*., 2014). It is being cultivated in all the seasons *viz*., *kharif, rabi* and *summer* with a production and productivity of 27.71 MT, 3.07 t/ ha during 2019 (FAO STAT, 2019). Maize genotypes respond to potassium application contrarily due to modification in its uptake, translocation, accumulation, growth and utilization. Potassium (K) is a macro element, it plays role in cell expansion and maintains turgidity. It helps in osmo- regulation of plant cell, assists in opening and closing of stomata and more than 60 enzymes are activated by potassium. Potassium protects the plant from both biotic and abiotic stress like diseases, pests, drought, salinity, water logging, frost etc, (Hasanuzzaman *et al.*, 2018). India is the major producer and consumer of sugar in the world. Molasses based distillery along with their product (alcohol) generate wastewater called spent wash. In general, the treated effluent contains the considerable amount of N and P, rich in K, Ca, Mg and S and the trace amount of Zn, Cu, Fe and Mn. However, the annual treated distillery effluent obtained in India can supply 16,800 tonnes of N, 6,300 tonnes of P and 1,26,000 tonnes K. So, the distillery effluent contains more amounts of organic and inorganic nutrients, this could be used as fertilizer for refining crop growth and soil fertility (Sukanya *et al.,* 2002; Joshi *et al.,* 2000). It is a well known fact that availability of organic manures is very much limited in the present day agriculture. Therefore, the application of nutrients needs to be increased to keep the soil fertile and to make agriculture sustainable. Now a days, nutrients are applied through inorganic fertilizers. Apart from fertility and productivity issues, use of chemical fertilizers is also becoming more and more difficult for the farmers due to their high costs and scarcity during peak season. On the other hand during recent years, sugar industries are producing large amount of waste products some of which are rich sources of macro, micro and secondary nutrients. The distillery spent wash can be utilized in agriculture for irrigation purpose, as fertilizer**,** a source of renewable energy and as manure. The resulting ash from distillery spent wash after incinerating is found to contain on an average of about 37 per cent of potash as potassium oxide. It can also be used as potassium salts. The use of this VAP as a K source with other nutrients helps to enhances the quality of crops, ensure sustainable productivity and nutritional security. While acting as a substitute for potassium fertilizer this will also increase the income of farmers in a long run and also it is a feasible option for safer disposal of the wastes. Holding this in mind, we set out to investigate the impact of applying VAP as a potassium source from distillery spent wash on various growth and yield parameters of maize (*Zea mays* L.) crop.

2. MATERIALS AND METHODS

The field experiment was conducted in the farm at Agricultural College and Research Institute, Kudumiyanmalai, Pudukkottai, Tamil Nadu, India in *kharif* season*,* 2020. It was laid out in randomized block design with seven treatments and three replications. The maize hybrid COHM (8) used as a test crop for this study and the crop duration was 95 days. The treatments include absolute control (T1), 50% STCR-K through VAP (T2), 75% STCR-K through VAP (T3), 100% STCR-K through VAP (T4), 125% STCR-K through VAP (T5), 50% STCR-K through VAP + 50% STCR-K through inorganic fertilizers (T6) and 100% STCR-K through inorganic fertilizer (MOP) (T7). The full dose of nitrogenous and phosphatic fertilizers were applied based on STCR through inorganic fertilizers as urea and SSP respectively to all the treatments except in control plot. Initial properties of the experimental soil was presented in Table 1. The characteristics of VAP collected from the EID parry industry, Nellikuppam was presented in Table 2. The characterization of distillery spentwash was also carried out by saranya *et al*., (2019).

Table 1: Initial soil properties of the experimental field

S.No.	Particulars	Values
Physical properties		
1	Bulk density (Mg m^{-3})	1.33
2	Particle density (Mg m^{-3})	2.25
3	Total porosity (%)	40
5	Soil texture	Red Sandy Loam
Chemical properties		
1	pH	7.81
2	EC (dS m^{-1})	0.30
3	Organic carbon (%)	0.51
4	Available Nitrogen (kg ha^{-1})	235.2
5	Available phosphorus (kg ha^{-1})	16.8
6	Available potassium (kg ha^{-1})	153.44
7	Exchangeable Calcium (c mol (p^+) kg^{-1})	8.54
8	Exchangeable Magnesium (c mol (p^+) kg^{-1})	5.96
9	Exchangeable Sodium (c mol (p^+) kg^{-1})	3.92
10	Exchangeable Potassium (c mol (p^+) kg^{-1})	1.17
Biological properties		
1	Bacterial population (10^{-6}) (CFU g^{-1} soil)	15.21
2	Fungal population (10^{-4}) (CFU g^{-1} soil)	5.35
3	Actinomycetes population (10^{-2}) (CFU g^{-1} soil)	2.07
4	Soil dehydrogenase (µg TPF g^{-1} soil hr^{-1})	2.15
5	Soil urease (µg NH_4 - N g^{-1} of soil hr^{-1})	1.86
6	Soil phosphatase (µg p-nitrophenol g^{-1} of soil hr^{-1})	5.48

Table 2: Characterization of Value Added Product (VAP)

S.No.	Particulars	Values
Physical properties		
1	Bulk density (Mg m^{-3})	0.80
2	Particle density (Mg m^{-3})	1.05
3	Total porosity (%)	24.00
4	Moisture content (%)	9.85
Chemical properties		
1	pH	8.45
2	EC (dS m^{-1})	7.71
3	Organic carbon (%)	15.39
4	Total potassium (%)	11.32

The growth parameters like plant height (cm) and leaf area index (LAI) were recorded at different growth stages. The crop was harvested when it attained maturity. The yield and yield parameters were reported after the maize cobs in the net plots were threshed to separate the grains. Yield parameters like cob length, cob girth, cob weight, number of rows per cob, number of grains per row, number of seeds per cob, and test weight were recorded. Stover yield was recorded after sun drying the harvested plants.

3. Results and Discussion

3.1 Effect of VAP application on different growth parameters of maize crop

3.1.1 Plant height (cm)

The data pertaining to plant height as influenced by VAP from distillery industry are presented in Table 3. At 30th and 60th day, the maximum plant height was recorded in 125% STCR-K through VAP (134.0cm and 267.3cm) which was on par with 100% STCR-K as VAP (123.7cm and 240.4cm) followed by 75% STCR-K through VAP (118.0cm and 231.2cm). The lowest plant height (86.9cm and 147.3) was observed in control. At harvesting stage, the plant height ranged from 180.6 to 290.6 cm. Among the different treatments imposed, the addition of 125% STCR-K through VAP produced the maximum plant height of 290.6cm followed by 100% STCR-K through VAP (270.4cm). The minimum plant height was registered in control (180.6cm).

Table 3. Plant height (cm) as influenced by graded levels of VAP at various stages of maize crop

Treatments	Plant height (cm)		
	30th DAS	60th DAS	90th DAS
T_1 - Absolute control	86.9	147.3	180.6
T_2 - 50% STCR-K through VAP	107.5	200.2	230.2
T_3 - 75% STCR-K through VAP	118.0	231.2	260.5
T_4 - 100% STCR-K through VAP	127.0	240.4	270.4
T_5 - 125% STCR-K through VAP	134.0	267.3	290.6
T_6 - 50% STCR-K through VAP + 50% STCR-K through MOP	113.0	217.4	244.1
T_7 - 100% STCR-K through MOP	117.7	215.6	245.6
SEd	6.30	13.26	8.48
CD(P=0.05)	13.74	28.89	18.49

Mean of three replications

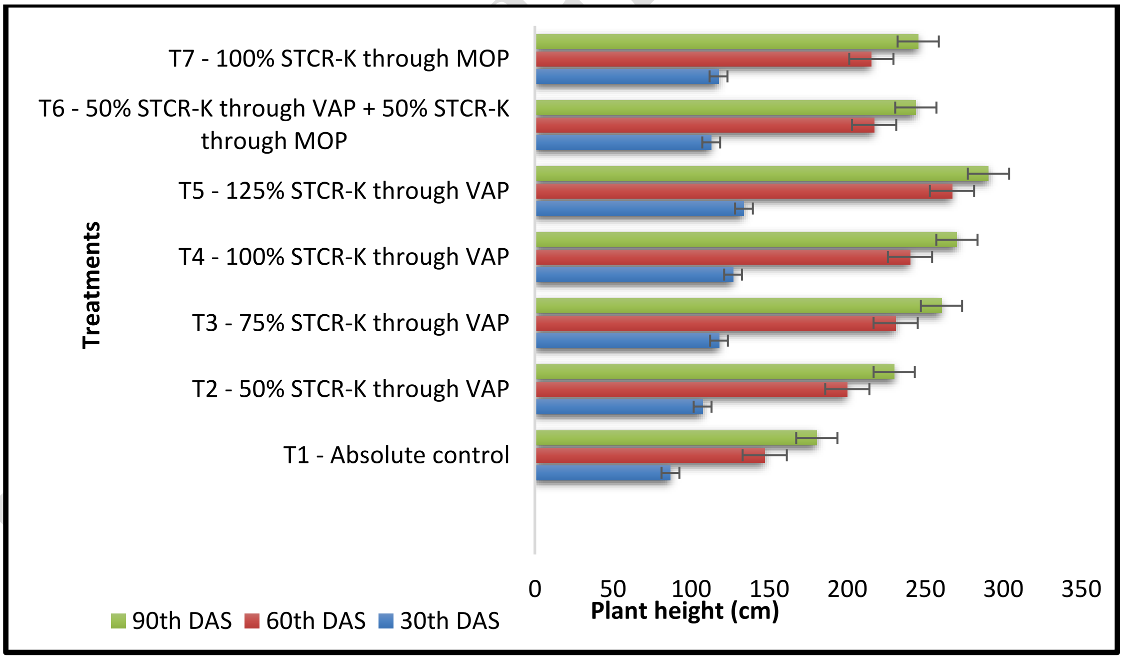

Fig 1. Plant height (cm) as influenced by graded levels of VAP at various stages of maize crop

3.1.2 Leaf Area Index

The LAI at 30 DAS show significant difference due to the effect of VAP application from distillery spent wash (Table 6). Significantly higher LAI was observed at 30 DAS in 125% STCR-K through VAP (1.906) which was on par with 100% STCR-K through VAP (1.795) followed by 75% STCR-K through VAP (1.732). Significantly lowest LAI at 30 DAS (0.901) was observed in control (T_1). At 60 and 90 DAS higher LAI was observed in treatment receiving 125% STCR-K through VAP (T_5) (4.133 and 5.246, respectively) on par with application of 100% STCR-K through VAP (T_4) (3.902 and 5.112, respectively) and application 75% STCR-K through VAP (T_3) (3.867 and 4.945, respectively). Lowest LAI at 60 and 90 DAS (2..693 and 3.692, respectively) were observed in control (T_1).

Table 4. Leaf area index (LAI) as influenced by graded levels of VAP at various stages of maize crop

Treatments	Leaf Area Index		
	30th DAS	60th DAS	90th DAS
T_1 - Absolute control	0.901	2.693	3.692
T_2 - 50% STCR-K through VAP	1.466	3.590	4.537
T_3 - 75% STCR-K through VAP	1.732	3.867	4.945
T_4 - 100% STCR-K through VAP	1.795	3.902	5.112
T_5 - 125% STCR-K through VAP	1.906	4.133	5.246
T_6 - 50% STCR-K through VAP + 50% STCR-K through MOP	1.627	3.553	4.626
T_7 - 100% STCR-K through MOP	1.573	3.573	4.518
SEd	0.06	0.12	0.20
CD(P=0.05)	0.14	0.27	0.43

Mean of three replications

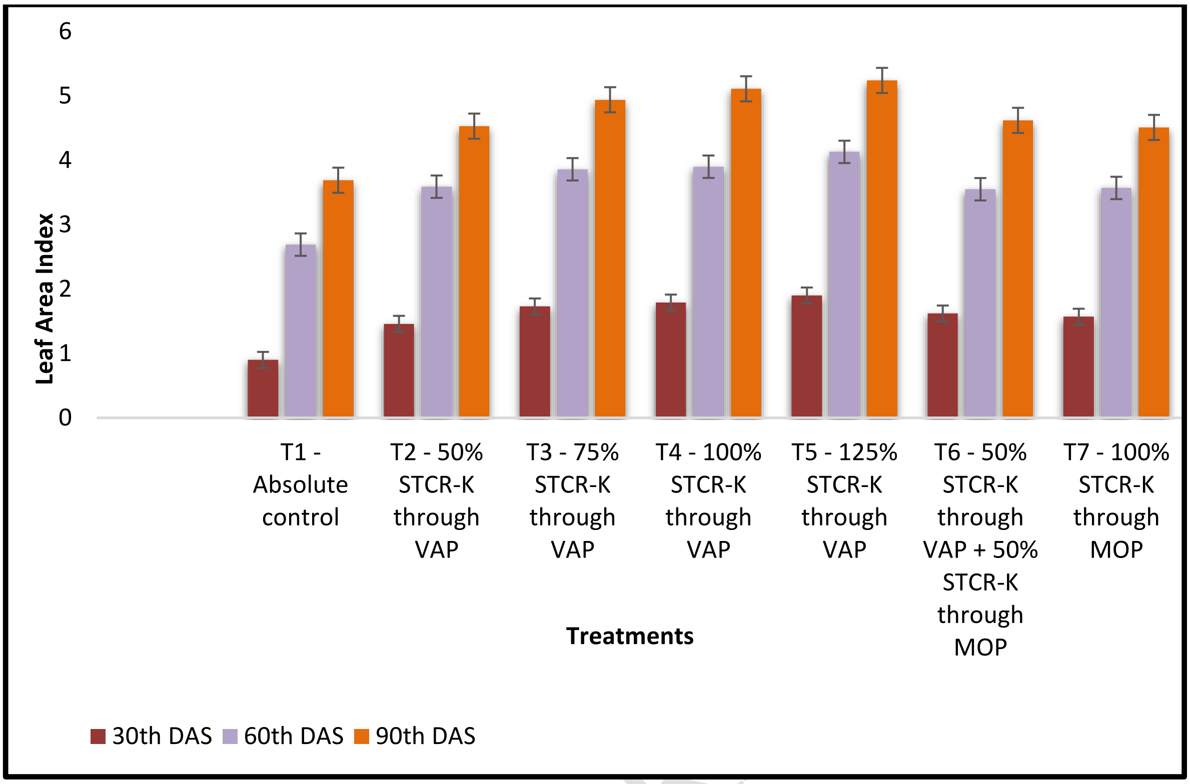

Fig 2. Leaf area index (LAI) as influenced by graded levels of VAP at various stages of maize crop

The results revealed that all the growth parameters were increased by the application of 125% STCR-K as VAP which was on par with 100% STCR-K as VAP and 75% STCR-K as VAP. Potassium released from VAP has significant influence in growth parameters like plant height and LAI of maize when compared to potassium released from MOP. The increase in plant height with higher K doses might be attributed to the fact that higher potassium doses promoted plant growth, increased the number and length of the internodes due to more cell division and cell elongation which in turn resulted higher plant height. The improvement in vegetative stage might be due to enhanced cell division, cell wall expansion, meristematic activity, photosynthetic efficiency and regulation of water intake into cells (Raju *et al.*, 2017). Amanullah *et al.,* (2016) reported that maximum leaf area index was recorded for the plots treated with the highest K level. The findings are in accordance with (Swetha *et al.,* 2017) and (Gnanasundari *et al*., 2018), who suggested that improvement in growth parameters with potassium application might be due to delayed leaf senescence, sustained leaf photosynthesis and better vegetative growth. This findings are in accordance with Kumar (2014), who suggested that potassium from effluent play a significant role in nutrient and sugar translocation in plants and maintains turgor pressure in plant cells. Doddamani *et al*. (2014) reported that, long-term spent wash application, improved the available status of N, P, K and micronutrients as evident by soil analysis. This facilitated better growth, dry matter accumulation and chlorophyll content of maize plants under spent wash compared to only fertilizer applied plots. These results corroborate with the findings of Suganya and Rajannan (2009), who also reported that the growth attributes of maize like plant height, leaf length, leaf breadth, number of leaves per plant and leaf area index were higher in distillery effluent irrigated treatments compared to control.

3.2 Effect of VAP application on different yield parameters and yield of maize crop

3.2.1 Cob length and Cob girth (cm)

The cob girth of maize ranged from 12.1 to 15.1 cm. However, the highest cob girth (15.1 cm) was recorded in the treatment received T_5 (125% STCR-K through VAP) which was on par with and T_4 (100% STCR-K through VAP) and T_3 (75% STCR-K through VAP) by recording the cob girth of 14.8 and 14.5 cm respectively and lowest in Control (T_1) (12.1cm).

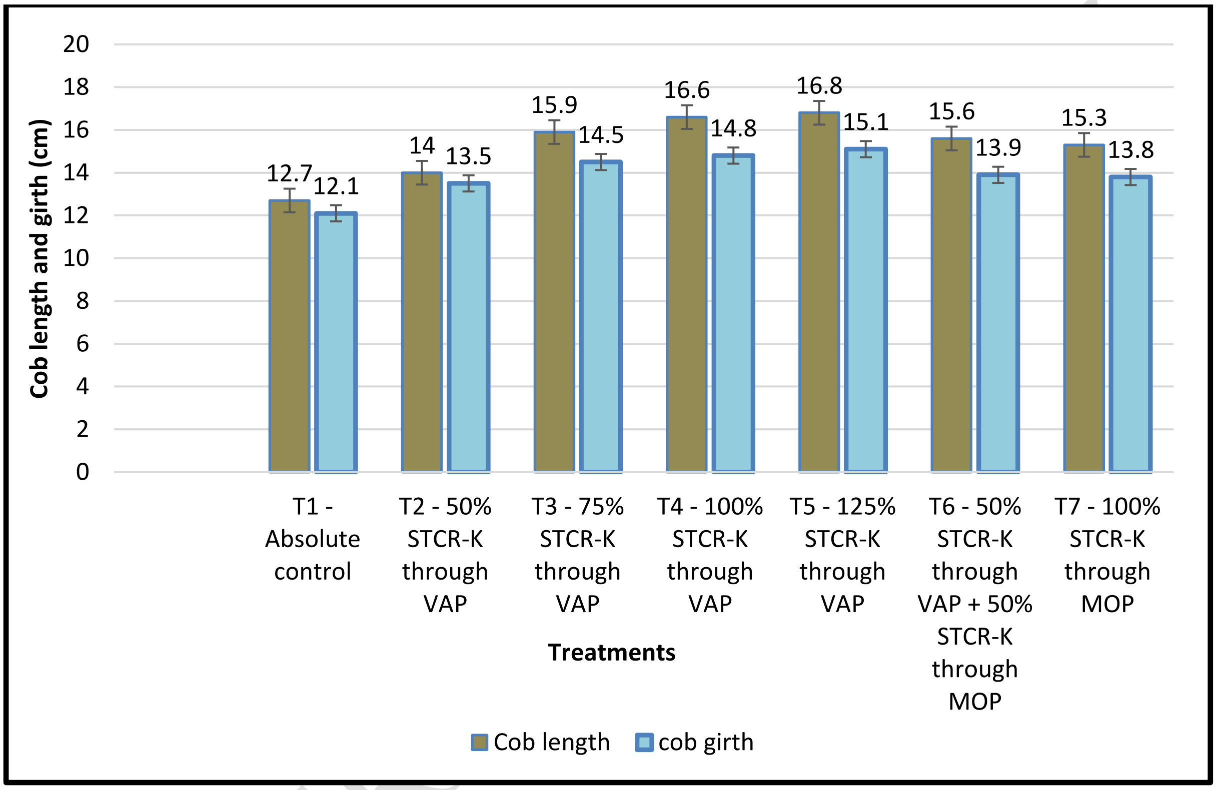

Fig 3. Cob length and Cob girth as influenced by graded levels of VAP

3.2.2 Number of grains per cob, No. of grain rows per cob and No. of grains per row

The perusal of data on number of grains per cob indicated the significant difference was observed between the treatments. The highest number of grains per cob (467.2) was recorded in treatment received T_5 (125% STCR-K through VAP) and lowest number of grains per cob (278.2) was recorded in Control (T_1). The number of grain rows per cob showed a significant difference between the treatments due to application of graded levels of VAP and inorganic nutrients. Application of T_5 (125% STCR-K through VAP) recorded the highest number of grain rows per cob (15.1) and lowest number of grain rows per cob was recorded in Control (T_1) (11.9). The number of grains per row was differed significantly due to application of graded levels of VAP. The number of grains per row ranged from 23.2 to 30.9. The highest number of grains per row (30.9) was recorded in treatment T_5 which received (125% STCR-K through VAP and the lowest number of grains per row (23.2) was recorded in Control (T_1).

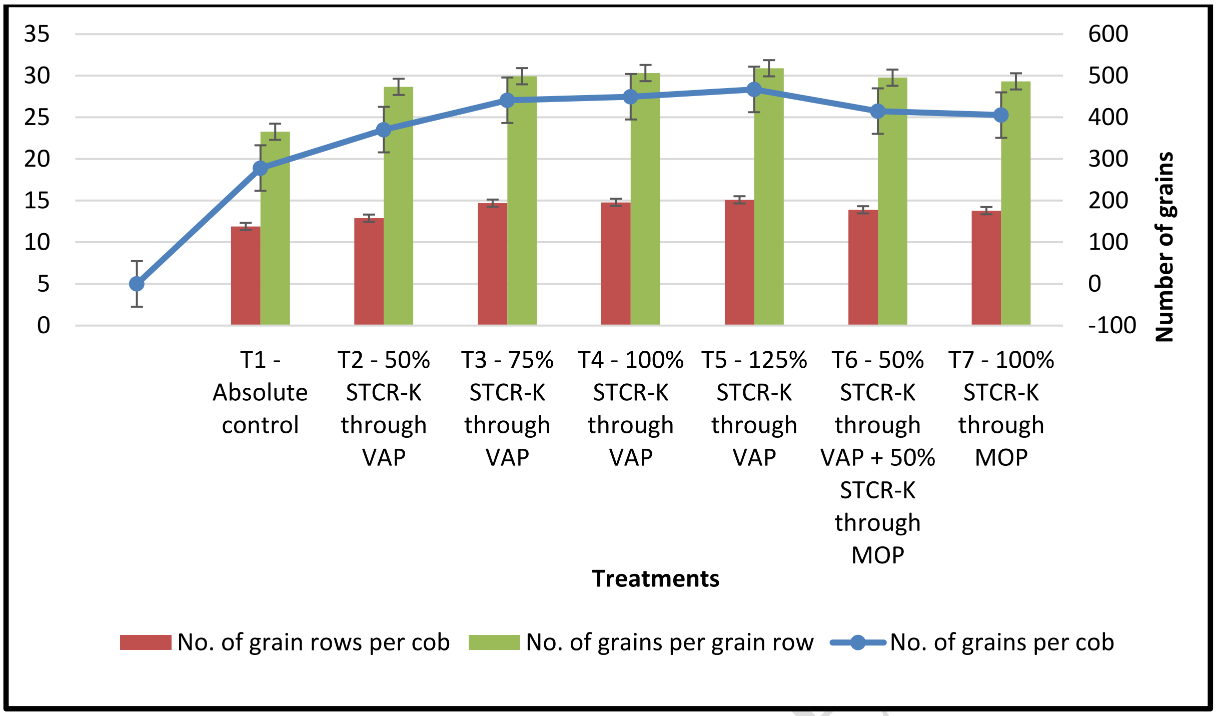

Fig 4. Number of grains per cob, No. of grain rows per cob and No. of grains per row as influenced by graded levels of VAP

3.2.3 Test weight and Cob weight

The weight of cob was significantly influenced by application of graded levels of VAP as well as different levels of inorganic nutrients. It was seen that the application of (125% STCR-K through VAP) was exhibited higher cob weight (104.1 g) which was on par with and T_4 (100% STCR-K through VAP) and T_3 (75% STCR-K through VAP) by recording the cob weight of 98.6 g and 95.8 g respectively and lower cob weight (58.3 g) was recorded in Control (T_1). The data on test weight indicated that a significant difference was existed between the treatments. The treatment received (125% STCR-K through VAP) recorded the highest test weight of 26.5 g which was on par with and T_4 (100% STCR-K through VAP) and T_3 (75% STCR-K through VAP) by recording the test weight of 26.1 g and 25.5 g respectively and the lowest test weight (19.5 g) was recorded in Control (T_1).

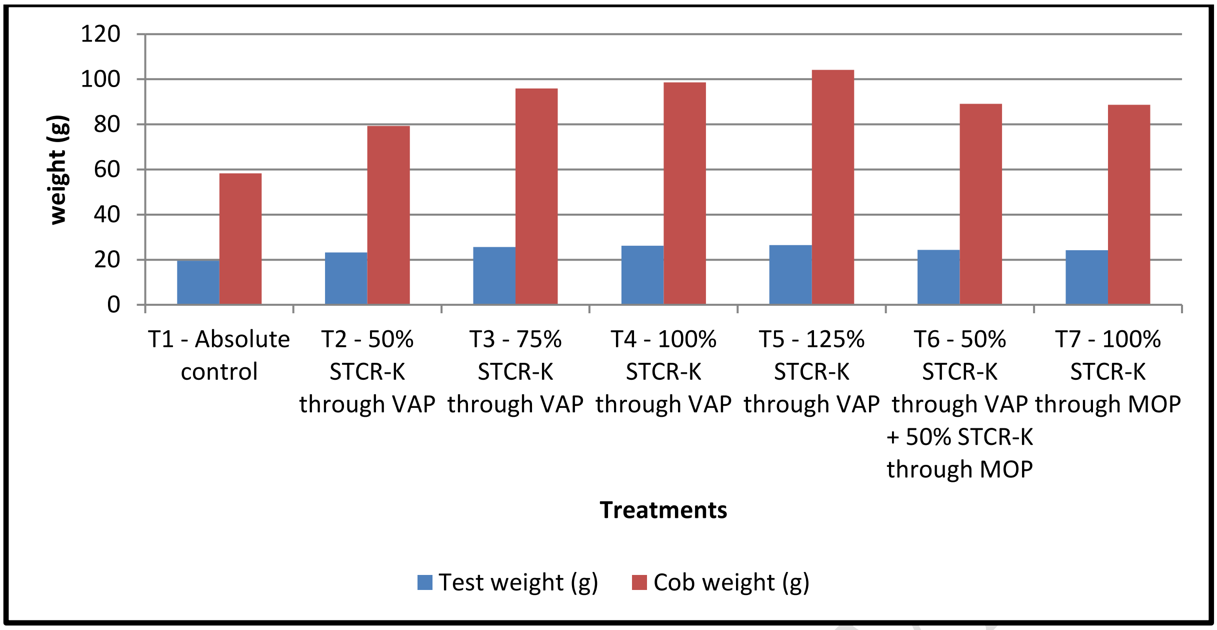

Fig 5. Test weight& Cob weight of maize grains as influenced by graded levels of VAP

3.2.4 Grain yield and Stover yield of maize

The grain yield and Stover yield of maize was found to be influenced significantly by the application of value added product (VAP) along with inorganic fertilizer. The maize grain yield ranged from 3011 to 6875 kg ha^{-1}. Application of (125% STCR-K through VAP) recorded the highest grain yield of 6875 kg ha^{-1} and the lowest grain yield (3011 kg ha^{-1}) was recorded in Control (T_1).

The perusal of data on Stover yield showed that a significant difference between the treatments due to the application of graded levels of VAP. The highest Stover yield (8954 kg ha^{-1}) was recorded in treatment which received (125% STCR-K through VAP) (T_5) and lowest Stover yield (5029 kg ha^{-1}) was recorded in Control (T_1).

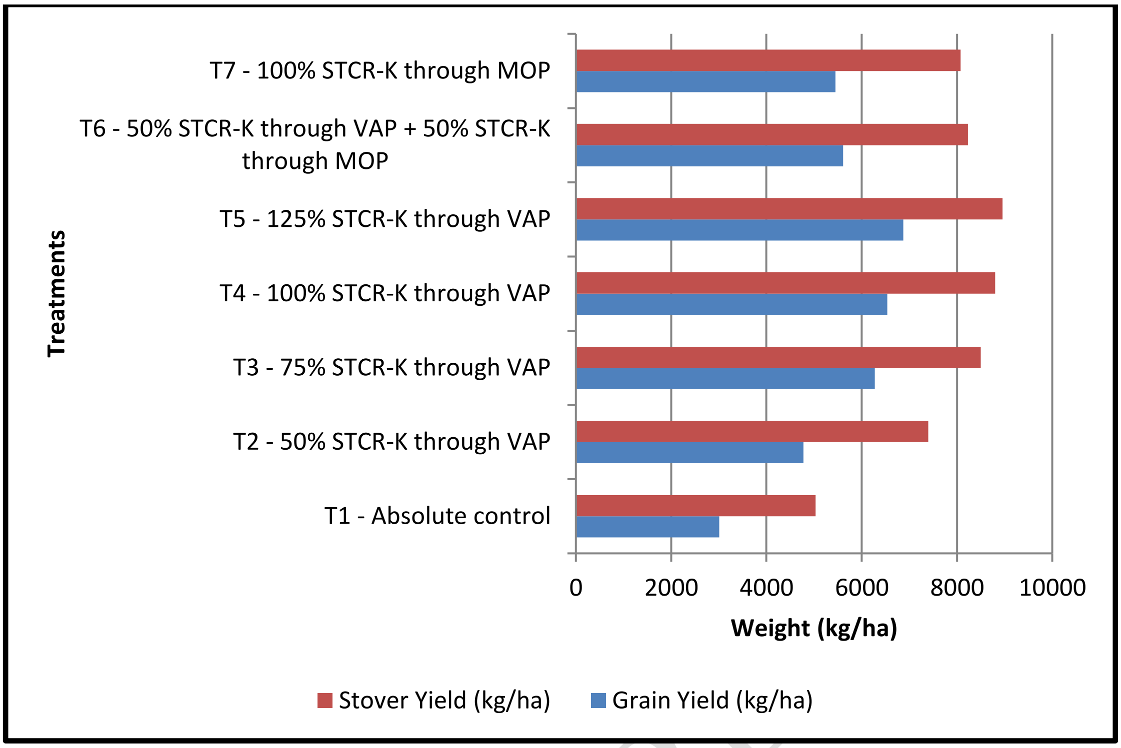

Fig 6. Grain yield and Stover yield of maize as influenced by graded levels of VAP

Table5: Influenced by graded levels of VAP on yield attributes and yield of maize crop

Treatments	Cob length (cm)	Cob girth (cm)	No. of grains per cob	No. of grain rows per cob	No. of grains per grain row	Test weight (g)	Cob weight (g)	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})
T_1 - Absolute control	12.7	12.1	278.4	11.9	23.2	19.5	58.3	3011	5029
T_2 - 50% STCR-K through VAP	14.0	13.5	370.7	12.9	28.6	23.1	79.3	4777	7400
T_3 - 75% STCR-K through VAP	15.9	14.5	441.3	14.7	29.9	25.5	95.8	6272	8500
T_4 - 100% STCR-K through VAP	16.6	14.8	449.7	14.8	30.3	26.1	98.6	6537	8800
T_5 - 125% STCR-K through VAP	16.8	15.1	467.2	15.1	30.9	26.5	104.1	6875	8954
T_6 - 50% STCR-K through VAP + 50% STCR-K through MOP	15.6	13.9	415.2	13.9	29.7	24.3	89.1	5607	8233
T_7 - 100% STCR-K through MOP	15.3	13.8	405.6	13.8	29.3	24.1	88.6	5448	8077
SEd	0.51	0.50	13.73	0.51	1.55	1.05	3.81	194.6	273
CD (p = 0.05)	1.11	1.09	29.92	1.13	3.37	2.30	8.31	423	596

Mean of three replications

Being a plant origin, the value added product is rich in OC, and contains considerable levels of N, P and rich in K which were made available to the plants by mineralization thus, resulting in better growth, development and yield of the crop. This was possible due to the sustained supply of nutrients throughout the crop growth period by mineralization as indicated by higher microbial population and enzymatic activities in VAP applied plots than control and the plots received only Recommended Dose of Fertilizers. Doddamani *et al*. (2014) reported that, Spent wash when applied as a substitute for nitrogenous fertilizer acted as a good source of potassium for the crop. Spent wash treated maize plots showed higher uptake of potassium. Potassium uptake in turn resulted in higher yield of maize. Aslam *et al. (*2004) found that potassium increased the activity of enzymes involved in carbohydrate translocation and deposition from source to sink, resulting in heavier grains. Continuous filling of grains with sufficient photosynthates lead to increased size of cob and also resulted in increased cob girth. Higher cob diameter was also attributed to the supply of sufficient NPK nutrients essential for constituents of plant tissues involved in cell division and cell elongation (Gul *et al*., 2015). More nutrient availability resulting in higher leaf area index resulted in higher availability of assimilates thereby resulting in improved number of rows per cob (Gul et al., 2015). Mallika, 2001 reported that, the cob length, single cob weight, 100 grain weight and grain yield increased in maize due to the application of spent wash at 150 kL ha-1. Similarly, Sridharan (2007) concluded that one time land application of post methanated distillery spent wash at 60 m^3 ha^{-1} increased the yield of rainfed maize. Ramana *et al*. (2002) reported that, highest grain yield of maize was linked with larger size of the cobs, higher number of seeds per cob by effluent application but it was not equivalent to the recommended dose of NPK + FYM due to imbalance supply of nutrients. Adiveppa *et al*. (2014) reported that application of distillery spent wash resulted in higher grain yield and stover yield. Due to its nutritional effects, improvement in physical and chemical properties of the soil lead to higher grain. Higher stover yield was due to higher soil available nitrogen. The results indicated that treatment receiving 150% N through distillery spent wash R.O. reject recorded significantly higher grain and stover yield than the plots receiving recommended dose of fertilizers only.

4. Conclusion

The combined management of soil, crop, climate and use of resources was necessary to provide the favorable environment for crop growth which directly influenced the growth and yield attributes of the crop. The application of 125 percent STCR-K through VAP had a significant impact on the crop's growth and yield attributes. Although 125 percent STCR-K through VAP provided better yield characteristics than 100 percent STCR-K through VAP and 75 percent STCR-K through VAP, it was comparable to 100 percent STCR-K as VAP and 75 percent STCR-K through VAP. As a result, the increase in yield was significant up to 75 percent STCR-K through VAP, indicating that the plants received nutrients from native sources and used VAP for growth at this time, and that the amount of nutrients provided was sufficient to achieve higher yield. Now a day's nutrients are supplied only through inorganic fertilizers in imbalanced proportion. continuous application of inorganic fertilizers leads to pollution problems, salinity of soil and water. So, it is concluded that application or utilization of VAP from distillery spent wash in crop production serves as a nutrient source to crop throughout the growth period, and also improves fertility status of the soil due to addition of organic matter and improve the biological properties of soil. Thus, the application of VAP will be a valuable substitute for inorganic fertilizers as well as safe option for disposal of the distillery industry waste.

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