Original Research Article

Effect of indigenous potash sources on growth, yield and quality of cauliflower (*Brassica oleracea* var. *botrytis*)

Abstract

A field experiment was carried out using RBD design with 10 treatments and 3 replications at the main campus, UHS, Bagalkot. Sugar industry by-products such as incinerated ash, distillery sludge and distillery sludge ash were utilised in the experiment to examine their effect as potassium sources on growth, yield and quality of cauliflower. These three distillery byproducts were applied as 100, 50 and 25 per cent as replacement for chemical potassium fertilizer (K_2SO_4). As a control, the final treatment was 100 per cent potassium sulphate. The N and P were supplied through urea and DAP respectively as per the recommended dose of fertilizers (RDF). . The higher contents of both primary and secondary nutrients (N, P, K, Ca, Mg and S) were observed in the treatment where 25 % of chemical fertilizer was replaced by incinerated ash. The content of these major nutrients and its uptake by the cauliflower plant was significantly higher with the treatment T_4 (25 % K through incinerated ash + 75 % through K_2SO_4). Significantly higher curd yield (15.86 t ha^{-1}) was associated with the treatment where 25 % of potassium supply was through incinerated ash.

Keywords: Potassium, cauliflower, incinerated ash, distillery sludge, distillery sludge ash

Introduction

Potassium (K) is an essential nutrient for plant growth and is absorbed from the soil as K^+ ions. It is ubiquitously present throughout the plant, but more so in meristematic cells or tissues such as root tips, buds and leaves. Functions of potassium include protein synthesis, osmotic potential modulation and turgidity regulation. It is essential for the opening and closure of stomata as well as the activation of specific enzymes. The entire requirement for potassium fertilizers in India is satisfied by import. Although the use of synthetic fertilizers increases crop output, but the degradation of physical, chemical and biological qualities of the soil besides raise input costs cannot be undermined. At the moment, recycling various organic wastes rich in organic matter turns them into valuable commodities and ensures hygienic disposal of organic wastes. During the evaporation of spent wash, a solid material known as 'distillery sludge' is created. The distillery sludge contains a high concentration of macro and micro nutrients. The burnt distillery solid waste is known as distillery sludge ash, and it is incinerated ash when it is burned in a closed container at a very high temperature while generating electricity. To test the efficacy of these distillery by products as potassium source on crop growth, cauliflower (*Brassica oleracea* var. *botrytis*) was selected as test crop.

Cauliflower requires considerable amount of nutrients for growth and development. The primary macro nutrients, phosphorus and potassium are important for plant growth, maturity, curd yield and quality of cauliflower.The most crucial element for cauliflower productivity is potassium. The significant impacts of potassium on plants include better food quality, increased plant tolerance to disease and drought stress.

Materials and methods

The experiment was conducted in the research field of MHREC, College of Horticulture, UHS, Bagalkot, Karnataka. Bagalkot comes under Karnataka state which is located in Northern region of state and it is the dry zone that receives an average rainfall of 682 mm per annum. It is situated at an elevation of 542.0 m above the sea level and has a latitude of $16^{0}.18''$ North and longitude of $75^{0}.7''$ East. It was conducted during rabi season *i.e.*, from November 2020 to January, 2021. The soil of the experimental field is red sandy loam. Before commencement of the experiment and after the completion of the experiment, composite soil sample were collected from 0-20 cm depth and the chemical properties of the experimental site were analysed. The experiment was laid out in a completely randomized design with ten treatments and three replications. T_1: 100 % Incinerated ash, T_2:100 % Distillery sludge, T_3:100 % Distillery Sludge ash, T_4: 25 % Incinerated ash + 75 % K_2SO_4, T_5: 25 % Distillery Sludge + 75 % K_2SO_4, T_6: 25 % Distillery Sludge ash + 75 % K_2SO_4, T_7: 50 % Incinerated ash + 50 % K_2SO_4, T_8: 50 % Distillery Sludge+ 50 % K_2SO_4, T_9: 50 % Distillery Sludge ash + 50 % K_2SO_4 and T_{10}: 100 % K_2SO_4. Incinerated ash contained 1.2 % P_2O_5, 12.6 % K_2O, 3.45 % Ca, 11.2 % Mg and 0.02 % S. Distillery sludge was having 1.33, 2.40, 9.16, 9.10 and 4.19 percentages of P_2O_5, K_2O, Ca, Mg and S respectively. Distillery sludge ash contained 4.71% P_2O_5, 0.6 % K_2O, 4.94% Ca, 3.04 % Mg and 0.06% S. Seedlings having uniform growth and vigour were transplanted at a spacing of 45 X 30 cm with plot size of 4 X 3 m^2. The observations were recorded on randomly selected five plants from each plot for various growth, yield and quality parameters.

Results and discussion

Soil available nutrients

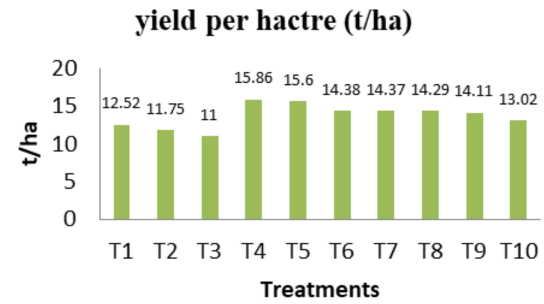
Data presented in Table 1, Table 2 and figure 1 clearly indicated that, a significant difference with regards the content of primary and secondary nutrients in soil, their uptake by cauliflower and yield parameters was recorded. Application of 25% potassium through incinerated ash plus 75% potassium through potassium sulphate found higher nitrogen content (339.20 $kgha^{-1}$). Lowest available nitrogen was associated with 100% potassium through distillery sludge ash (179.02 $kgha^{-1}$). According to Das *et al.*, (2013) and Lal *et al.*, *(*2015), this could be attributable to the addition of chemical fertilizers as well as distillery by-products. Significantly higher (T4: 82.75 $kgha^{-1}$) phosphorous was noticed with application of 25% incinerated ash plus 75 % potassium sulphate. This was owing to organically bound phosphorus in distillery by-products, which takes a long time to degrade into usable form. Significantly lower available P_2O_5 in soil was observed in 100% potassium through distillery sludge ash (55.13 $kgha^{-1}$). The highest potassium content was recorded by application of 25 % incinerated ash plus 75% potassium sulphate (T_4: 642. 59 $kgha^{-1}$). The minimum potassium content in soil was observed in treatment T_3 (103. 45 $kgha^{-1}$). Higher potassium content in soil was attributed to higher potassium content of incinerated ash (12.5% K). Because the potassium in the ash is in ionic form applying the ash to the soil immediately increases the amount of K available in the soil. Similar results were found by (Kulkarni *et al.* (1987), Das *et al.* (2013) and Hamsa (2015). The highest exchangeable calcium and magnesium were recorded with the application of 25% of incinerated ash plus 75% potassium sulphate {T_4: 9.22 and 5.10 (c mol (p+) kg^{-1})}. The minimum calcium and magnesium were with the application of 100% distillery sludge ash {T_3: 8.09 and 1.86 (c mol (p+) kg^{-1})}. An increase in exchangeable calcium and magnesium in the soil might be due to the presence of high amount of calcium and magnesium in these distillery by-products, especially in incinerated ash as reported by Jayasinghe *et al.* (2009). The treatment T_4 (25% incinerated ash + 75% K_2SO_4) recorded higher (22.09 ppm) available sulphur content and T_3 recorded lower (7.99 ppm) available sulphur content which constituted 100% distillery sludge ash. Due to the presence of appreciable amount of sulphur in these indigenous sources and they helped in mobilizing the sulphur from the soil as reported by Surekha (2005).

Uptake of nutrients

Significantly higher nitrogen uptake by leaf, stem, root, and curd was observed in 25% K through incinerated ash plus 75% K through potassium sulphate. Higher uptake was supported by the increased availability of nutrients in soil under distillery by-products treatments. Phosphorous uptake by leaf, stem, root, and curd differed due to the influence of distillery by-product. It was significantly higher in treatment T_4 (25% incinerated ash plus 75% potassium sulphate). Higher uptake of phosphorus is due to the application of incinerated ash in combination with chemical fertilizers. Sireesha and Rani (2014) also found that spent wash application outperformed other sources in terms of P uptake. Potassium uptake by leaf, stem, root, and curd varied significantly and ranged between 102.43 and 277 kg/ha. Application of 25% potassium through incinerated ash plus 75% of potassium through potassium sulphate recorded the highest potassium uptake. Significantly lower potassium uptake was observed with 100% potassium through distillery sludge ash. This could be due to the larger availability of residual potassium in soil solution, which is available in ionic form, as a considerable amount of potassium is delivered to the soil when distillery wastes are applied. Calcium uptake by leaf, stem, root, and curd varied significantly among by-products. Higher uptakes of calcium and magnesium by leaf, stem, root, and curd were observed in 25% potassium through incinerated ash. Lower calcium and magnesium uptakes were observed in 100% potassium through distillery sludge ash. It could be because spent wash contains a significant amount of calcium and magnesium, which boosts crop uptake and build-up. Korndorfer (1990) showed improved calcium and magnesium availability in sugarcane crops after spent wash treatment. Significantly higher uptake of sulphur by different parts was found in 25% potassium through incinerated ash plus 75% potassium through potassium sulphate. Significantly lower sulphur uptake was observed with 100% potassium through distillery sludge ash. Sulphur content increased as a result of the use of distillery by-products, which could be due to more sulphur being added to the soil. Similarly, Hasmato and Yokoto (1965) found that applying paper mill effluent boosted sulphur uptake considerably.

Curd yield per hectare (t/ha)

Curd yield per hectare varied from 11.00 to 15.86 tons per hectare and the results differed numerically among the treatments as maximum (15.86 t/ha) curd yield per hectare was observed with the application of 25% incinerated ash plus 75% potassium sulphate (T_4) while least (11.00 t/ha) was observed with the application of 100% distillery sludge ash (T_3). Increased plant nutrient availability and balanced provision of all important elements through organic and inorganic sources may be owing to the combined application of incinerated ash and recommended fertilizer doses. Many additional researchers in India and other nations observed that distillery byproducts enhanced crop yields significantly. *viz.*, rice (Rajukkannu *et al*., 1996; Valliappan, 1998), sugarcane(Devarajan and Oblisami, 1995).



T_1: 100 % Incinerated ash, T_2:100 % Distillery sludge, T_3:100 % Distillery Sludge ash, T_4: 25 % Incinerated ash + 75 % K_2SO_4, T_5: 25 % Distillery Sludge + 75 % K_2SO_4, T_6: 25 % Distillery Sludge ash + 75 % K_2SO_4, T_7: 50 % Incinerated ash + 50 % K_2SO_4, T_8: 50 % Distillery Sludge+ 50 % K_2SO_4, T_9: 50 % Distillery Sludge ash + 50 % K_2SO_4 and T_{10}: 100 % K_2SO_4.

Fig 1: Effect of indigenous potassium sources on yield attributes of cauliflower

Conclusion

With respect of all the parameters studied, it can be concluded that, there was significant influence of distillery by products, especially incinerated ash on content and uptake of major nutrients and yield of cauliflower. Available nitrogen, phosphorous and potassium content and Exchangeable Ca, Mg and S of soil differed due to the application of distillery byproduct such as incinerated ash, distillery sludge and distillery sludge ash and highest amount of these three nutrients in soil was with the treatment T_4 (25% K through incinerated ash + 75% K through K_2SO_4). The highest nitrogen uptake of 205.05 kg/ha was observed with the treatment T_4 (25% K through incinerated ash plus 75% through K_2SO_4). Similar trend of nitrogen uptake was followed in case of P, K, Ca, Mg and S uptakes (205.05, 48.23, 277.00, 0.65, 0.33 and 18.53 kg ha^{-1}). Higher curd yield was recorded with application of 25incinerated ash plus 75% potassium sulphate (15.86t/ha).

Table 1: Effect of indigenous potassium sources on major nutrients in soils

Treatment	Nitrogen (kg/ha)		Phosphorous (kg/ha)		Potassium (kg/ha)		Calcium (c mol (p+) kg-$^{-1}$)		Magnesium (c mol (p+) kg^{-1})		Sulphur (ppm)	
	30 DAT	60 DAT	30 DAT	30 DAT	60 DAT	30 DAT	60 DAT	30 DAT	30 DAT	60 DAT	30 DAT	60 DAT
T_1-Incinerated ash	231.48 ^{efg}	217.71 ^{ef}	67.12 ^{cd}	8.71	8.48	2.8 ^{c}	2.16 ^{cd}	19.33 ^{d}	13.40 $_{cd}$	59.73 ^{cd}	280.36 $_{e}$	266.51 ^{d}
T_2-Distillery sludge	216.19 ^{fg}	211.23 ^{ef}	65.56 ^{cd}	8.55	8.37	2.76 ^{c}	1.93 ^{d}	19.15 ^{d}	13.0 ^{d}	56.31 ^{d}	142.23 $_{f}$	129.83 ^{e}
T_3-distillery sludge ash	188.90	179.02 ^{f}	61.03 ^{d}	8.31	8.09	2.5 ^{c}	1.86 ^{d}	14.31 ^{e}	7.99 ^{e}	55.13 ^{d}	115.34 $_{f}$	103.45 ^{e}
T_4-25% incinerated ash+75% K_2SO_4	351.74 ^{a}	339.20 ^{a}	88.4 ^{a}	10.95	9.22	5.56 ^{a}	5.1 ^{a}	29.24^{a}	22.09 ^{a}	82.75 ^{a}	661.26 $_{a}$	642.59 ^{a}
T_5-25% distillery sludge+75% K_2SO_4	338.06 ^{ab}	321.71 ^{ab}	85.51 ^{a}	10.52	9.05	4.93 ^{ab}	4.06 ^{ab}	25.46 ^{b}	19.71 $_{ab}$	80.62 ^{a}	647.89 $_{a}$	631.92 ^{a}
T_6-25%distillery sludge ash+75% K_2SO_4	318.75 ^{abc}	288.79 ^{bc}	84.2 ^{a}	9.88	9.01	4.9 ^{ab}	4.03 ^{ab}	20.43 ^{cd}	16.73 $_{bc}$	78.81 ^{a}	645.18 $_{a}$	628.91 ^{a}
T_7-50% incinerated ash+ 50% K_2SO_4	301.11 $_{abcd}$	283.11^{bcd}	75.66 ^{b}	9.09	8.97	3.86 ^{bc}	3.66 ^{b}	24.49 ^{b}	15.08 $_{cd}$	69.56 ^{b}	568.92 $_{b}$	552.41 ^{b}
T_8-50% distillery sludge + 50% K_2SO_4	288.15 ^{bcd}	279.69 $_{bcd}$	72.43 ^{bc}	8.95	8.91	3.66 ^{bc}	3.56 ^{b}	21.5 ^{c}	13.91 $_{cd}$	64.84 ^{bc}	535.40 $_{bc}$	519.34 $_{bc}$
T_9-50%distillery sludge ash + 50% K_2SO_4	281.10 ^{cde}	271.56 ^{cd}	70.51 ^{bc}	8.9	8.8	3.60 ^{bc}	3.36 ^{bc}	20.47 ^{cd}	13.04 $_{cd}$	62.89 ^{c}	489.23 $_{c}$	475.18 ^{c}
T_{10}-100% K_2SO_4	260.96 ^{def}	244.46 ^{de}	68.48 ^{bcd}	8.77	8.69	3.13 ^{c}	3.0 ^{bcd}	24.88 ^{b}	18.97 $_{ab}$	60.59 ^{cd}	341.45 $_{d}$	320.40 ^{d}
SE m+/-	17.844	14.333	2.818	0.697	0.677	0.495	0.459	0.457	1.242	1.856	19.118	19.381
CD (5%)	53.017	42.585	8.374	2.072	2.010	1.470	1.363	1.358	3.691	5.514	56.802	57.585

Table 2: Effect of indigenous potassium sources on total nutrient uptake by cauliflower

Treatments	Total 'N' uptake (kg/ha)	Total 'P' uptake (kg/ha)	Total 'K' uptake (kg/ha)	Total 'Ca' uptake (kg/ha)	Total 'Mg' uptake (kg/ha)	Total 'S' uptake (kg/ha)
T_1-Incinerated ash	129.20 [h]	40.57 [g]	105.17 [h]	0.47 [f]	0.25 [c]	14.56 [e]
T_2-Distillery sludge	120.20 [i]	39.22 [h]	104.33 [h]	0.45 [f]	0.21 [c]	12.44 [f]
T_3-distillery sludge ash	117.40 [j]	37.36 [i]	102.43 [i]	0.44 [f]	0.15 [d]	11.42 [g]
T_4-25% incinerated ash+75% K_2SO_4	205.05 [a]	48.23 [a]	277.00 [a]	0.65 [a]	0.33 [a]	18.53 [a]
T_5-25% distillery sludge+75% K_2SO_4	171.17 [b]	46.78 [b]	255.25 [b]	0.62 [ab]	0.32 [a]	17.53 [b]
T_6-25%distillery sludge ash+75% K_2SO_4	166.05 [c]	46.60 [b]	203.47 [c]	0.61 [bc]	0.31 [a]	16.66 [c]
T_7-50% incinerated ash+ 50% K_2SO_4	163.47 [d]	45.31 [c]	150.37 [d]	0.58 [cd]	0.30 [a]	16.57 [c]
T_8-50% distillery sludge + 50% K_2SO_4	160.46 [e]	43.42 [d]	116.28 [e]	0.55 [de]	0.30 [b]	16.48 [c]
T_9-50%distillery sludge ash + 50% K_2SO_4	156.83 [f]	42.38 [e]	113.52 [f]	0.54 [e]	0.26 [b]	15.69 [d]
T_{10}-100% K_2SO_4	138.97 [g]	41.51 [f]	109.30 [g]	0.54 [e]	0.25 [b]	15.63 [d]
SE m+/-	0.720	0.128	0.607	0.012	0.012	0.185
CD (5%)	2.140	0.381	1.802	0.034	0.035	0.550

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