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Research Article

Effect of Molasses and Organic Fertilizer in Soil fertility and Yield of Spinach in Khotang, Nepal

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Abstract

A field experiment was conducted at Diktel Rupakot Majhuwagadhi Municipality of Khotang district during April 14 to May 28 of 2018 to evaluate the effect of molasses and organic fertilizer in soil fertility and yield of Spinach (*Spinacia oleracea* var *'patane local'*). The effect of molasses and organic fertilizer in soil fertility and yield of spinach was evaluated by using RCBD (Randomized Complete Block Design) with five treatments and five replications. The five treatments were soil application of molasses, foliar application of molasses, molasses+organic fertilizer, organic fertilizer and controlled soil. The field was divided into 25 plots, each having an area of 1.2×1.2 m^2 and distance between each plot was 0.5m. Spacing of 30×15 cm^2 was maintained. The mean comparison was done through Duncan Multiple Range Test (DMRT). Molasses+organic fertilizer had highly significant result in soil organic carbon content (SOC), nitrogen, potassium, soil P^H and yield of Spinach. Higher soil organic carbon (4.51%), nitrogen (0.24%), potassium (557.80 mg/kg) and yield (3.08kg) was obtained at molasses+organic fertilizer whereas soil application of molasses had significantly low P^H (5.54). Poor soil fertility, lack of sustainable soil management, lack of chemical fertilizers was problems for declining crop productivity in Khotang district. The experiment suggests that, farmers could be benefitted by application of molasses and organic fertilizer as it improves soil fertility and increases the yield of spinach.

Keywords: Molasses; soil fertility; organic fertilizers; RCBD; DMRT; soil organic carbon

Introduction

Spinach (*Spinacia oleracea* L.) is a cool-season crop and belongs to the goose family (Amaranthaceae) which is native to central Asia (Morelock and Correll, 2008). Spinach is widely regarded as a functional food due to its diverse nutritional composition, which includes vitamins, minerals, and phyto-chemicals that maintains good health (Robert and Moreau, 2018). Spinach was found to be a good source of vegetable protein (11.10%), fiber (21.38%) moisture (36.8%), Ash (6.96), Carbohydrate (20.28%) and fat (3.47%) (Kavithal and Ramdas, 2013). Spinach is low in sodium content and it is best sources of phyto-nutrients and chlorophyll (Toledo *et al*., 2003). Spinach leaves contain several powerful and water-soluble natural antioxidants, which protect against the numerous degenerative diseases (Ko *et al*., 2014). Molasses is produced annually in large amounts and is used in different industries including animal feeding, alcohol and fertilizers.

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The use of sugar beet molasses in agriculture stimulates nutrient elements uptake efficiency and soil biological activity (Samavat and Samavat, 2014). Molasses has been used in the past as fertilizer and soil improver particularly on sandy soil and soil of poor structure (Barnes, 1954). Molasses supplies carbohydrates and alters C: N ratio which affects soil microbial ecology and lowers plant parasitic nematodes as well as provides other favorable effects on plant growth (Schenck, 2001). Filter mud cake, FYM and molasses increased NPK uptake and yields (Abo-Baker, 2017). Molasses improves soil aggregation and reduces surface crusting in hard-setting soils (Wynne and Meyer, 2002). Molasses sterilize soil partially and increase nitrogen fixation (Rouillard, 1954). Molasses are produced in large amount in Nepal and sugar industries are unable to sell molasses (Dhakal, 2018). There is scarcity of chemical fertilizer in Nepal (MoAD, 2016) due to difficult geography and lack of fertilizers producing industries (Dahal and Bhandari, 2019). Chemical fertilizer reduces soil fertility in long term and poses gigantic threat to agro-ecology (Zhang *et* al.,2018) thus molasses and organic fertilizer could be substitute to it in Nepal.

Materials and Methods

Experiment Location

Experiment is carried out in Diktel Rupakot Majhuwagadhi Municipality of Khotang District. Khotang is a hilly district situated in the eastern belt of Nepal. It has latitude of $27^0$1160.60" N and longitude of 86°46′59.99″ E. The altitude ranges from 142 masl to 3620 masl. Climate in Khotang ranges from tropical in foot hills to temperate in high hills with minimum temperature 5°C and maximum temperature 30°C. The average annual rainfall is recorded up to 168.9cm in Diktel. Soil is characterized by slightly acidic soil with clayey loam, loamy and sandy loam texture.

Experiment Design

The research was conducted in Randomized Complete Block Design comprising 5 Treatments replicated 5 times.

Treatment A: Soil application of molasses

Treatment B: Foliar application of molasses

Treatment C: Molasses + Organic fertilizers

Treatment D: Application of organic fertilizers

Treatment E: Control

Cultivation Techniques

Field preparation and layout: A fine pulverized soil was maintained by 2 deep ploughing with mini tiller followed by leveling of the soil. A 64m2 field was selected for the research with 5 treatments and 5 replications. Total field was divided into 25 plots with each plot having area of 1.44 m2 and the spacing between each plot is 0.5m

Seed rate and Spacing: Applied seed rate was 2 kg/ha. Each plot contained 4 rows of plants. Spacing between plants was maintained as 15 cm and spacing between rows was maintained at 30 cm.

Sowing: Spinach was directly sown in the field. It was sown in a row at depth of 2.5cm. Lines were drawn with the help of regular rope and sticks.

Thinning and re-planting: Thinning and replanting was done at 10 DAS.

Fertilizer application: Organic fertilizer was applied 2 days before sowing. A well decomposed organic fertilizer was applied in the field by mixing with the soil. Soil application of molasses was applied 2 times, first before 15 days of sowing and next after 15 days of first application. Molasses was applied as liquid formulation and sprayed in the soil by rose cane. Foliar spray was done with the help of sprayer as liquid formulation. Two bucketful per square meter organic matter (3 kg per plot) was applied at the time of application. Molasses application in soil was done at the rate of 1L/ha mixed with 50L/ha water and foliar application was done at the rate of 0.30L/ha mixed with 50L/ha water.

Irrigation and weed management: Irrigation was done at every 15 days interval to provide appropriate moisture to the soil. Manual weed management was done throughout the crop season

Harvesting: Manual harvesting was done after 45 days of sowing.

Soil Sample Collection and Preparation

Soil sample was taken from each plot after harvest to evaluate the nutrients present in soil samples. The surface soil samples (0-20 cm depth) were collected from each plot. Altogether 25 soil samples were collected from the research field by using soil sampling local tools. Composite sample was taken from each plot and they are collected in soil sampling bags.

Soil Sample Analysis

The collected soil samples were analyzed at Regional Soil Testing Lab, Jhumka. Methods of lab analysis of soil sample are shown in Table 1.

Statistical Analysis and Data Presentation

Date obtained from soil chemical analysis were analyzed both on descriptive and statistical basis. They were statistically analyzed using Genstat and Microsoft Excel. Data were subjected to analysis of variance (ANOVA) appropriate to one way randomized complete block design technique using Genstat. Means comparison was done using Duncan's Multiple Range Test (DMRT) at 5% significance levels.

Table 1: Methods of lab analysis of soil sample

Parameters	Study method
Soil texture	Mechanical analysis method
Soil pH	Glass-calomel electrode pH meter using
Organic	Walkley – Black method
Total	Kjeldhal distillation unit
Available	Modified Olsen bicarbonate method
Available	Ammonium acetate extraction method

Results and Discussion

The experiment was conducted to study the effect of molasses application on yield of spinach and nutrients status of the soil. Yield of spinach and nutrients content of soil was measured and the presence or the absence of significant difference between the parameters with different treatments were analyzed. The result of different parameters have been discussed and interpreted in this section.

Table 2: Effect of molasses and organic fertilizer in p^H of soil

Treatments	Soil p^H
Soil application of molasses	5.54^{c}
Foliar application of molasses	5.8^{ab}
Molasses+ organic fertilizers	5.82^{ab}
Organic fertilizer	5.76^{b}
Control	5.96^{a}
SEM(±)	0.05
LSD(0.05)	0.16^{***}
C.V.%	2.2
Grand mean	5.77

The maximum p^H was found on controlled soil (5.96) and the least was found on soil application of molasses (5.54) as shown in Table 2. The difference is statistically significant at 1% level of significance. Molasses stimulate the production of organic acids in the soil which helps to decrease p^H of the soil (Abo-Baker, 2017). The decomposition of molasses produces carboxylic groups which, after dissociation may decrease soil p^H. As soon as these groups are decarboxylated in the citrate cycle, an equivalent amount of protons is required inducing a rise in soil p^H. (Yan *et al.*, 1996).

The maximum SOC was found on combined application of molasses and organic fertilizer in soil (4.51) which was statically similar to soil and foliar application of molasses and least SOC was found on controlled soil (3.76). The difference is statistically highly significant at 1% level of significance. Molasses is a solution containing sugar and non- sugar components, palatable source of fermentable carbohydrates, which typically has high concentrations of calcium, sulfur but relatively little crude protein (Chikhoune *et al.*, 2014). Molasses contains 45 to 55 weight percent fermentable sugars in the form of sucrose, glucose, fructose and organic content including vitamins, minerals, proteins and amino acids (Raad, 2011). Organic fertilizer increase soil organic carbon content (Karazija *et al.*, 2015). The maximum nitrogen was found on treatment molasses and organic fertilizers and least was found on controlled soil (0.18) as shown in Table 3. The difference is statistically significant at 1% level of significance. Molasses increase rate of nitrification in soil (Cleasby, 1957). Organic fertilizer increase Nitrogen content in soil (Karazija *et al.*, 2015). Although there was no significant difference between treatments, available phosphorus was found maximum in control plot (5.54) and treatment organic fertilizer (5.54). Least was found in soil application of molasses (4.80). There was high significant difference between different treatments for available potassium. The maximum available potassium was found for treatment molasses and organic fertilizer (557.80), the least was found in controlled soil (264.60). The amount of increase in available potassium was proportional to the amount of molasses used. Molasses increases the soil available potassium (Sanli *et al.*, 2015). Organic fertilizer increase level of potassium in soil (Karazija *et al.*, 2015).

Table 3: Effect of molasses and organic fertilizer in Nutrient content of soil after harvest of Spinach

Treatments	SOC (%)	Nitrogen (%)	Phosphorus (mg/kg)	Potassium (mg/kg)
Soil application of molasses	4.40^{a}	0.21^{b}	4.80^{a}	276.20^{c}
Foliar application of molasses	4.08^{ab}	0.22^{b}	4.99^{a}	267.00^{c}
Molasses+ organic fertilizers	4.51^{a}	0.24^{a}	5.50^{a}	557.80^{a}
Organic fertilizer	4.47^{a}	0.22^{b}	5.54^{a}	468.60^{b}
Control	3.76^{b}	0.18^{c}	5.54^{a}	264.60^{c}
SEM(±)	0.15	0.007	0.55	28.60
LSD(0.05)	0.44^{***}	0.02^{***}	1.65^{ns}	85.70^{***}
C.V.%	7.90	7.40	23.50	17.40
Grand mean	4.25	0.21	5.24	363

Table 4: Effect of Molasses and organic fertilizer in yield of Spinach

Treatments	Yield(kg/plot)
Soil application of molasses	2.02[b]
Foliar application of molasses	1.54[c]
Molasses+ organic fertilizers	3.08[a]
Organic fertilizer	2.12[b]
Control	1.22[d]
SEM(±)	0.03
LSD(0.05)	0.09[***]
C.V.%	3.60
Grand mean	2.00

Yield was found maximum when organic fertilizer was applied along with molasses (3.08) and least yield was obtained in control plot (1.22) as shown in Table 4. The difference is significant at 1% level of significance. Molasses increased root and shoot length, and also root and shoot dry weight (Suliasih and Widawati, 2017). Sugarcane molasses showed better result in terms of shoot and root length, fresh and dry weight of tomato plant than ash or other source of nutrients (Vawdrey and Stirling, 1997). Application of molasses increase yield of leafy vegetables (Chandraju *et al.*, 2008).

Conclusion

Application of molasses and organic fertilizer increase Soil Organic Carbon, nitrogen, potassium and yield of spinach whereas molasses reduces soil p^H thus it will be better to suggest spinach growing farmers of Khotang district to apply molasses and organic fertilizer.

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