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Research Article

Effect of planting dates and sources of nitrogen on growth and yield of cauliflower at Rampur, Chitwan, Nepal

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ABSTRACT

Appropriate time of planting and use of suitable sources of nitrogen are highly conducive for better growth and yield of cauliflower. A field experiment was conducted to study the effect of planting dates and sources of nitrogen on growth & yield of cauliflower at horticulture research block of Agriculture and Forestry University, Rampur, Chitwan, Nepal from 1st Nov 2019 to 4th March 2020 using 'Snow mystic', a late season variety of cauliflower. The study was laid out in split-plot design with two dates of planting (Dec 1st & Dec 16th) as main plot factors & four sources of nitrogen viz. 100% biochar (BCH), 100% Urea(U), 50% urea+ 50% Poultry manure (U+PM) & 50% Biochar+ 50% poultry manure (BCH+PM) against a control as sub-plot factors and were replicated thrice with 30 experimental units each of 9 m2 size containing 5 rows with 5 plants per row. The recommended dose of fertilizer used for the research was 108:92:60 kg N, P2O5, K2O ha-1 and P and K were supplied through SSP and MOP. The soil of experimental plot was sandy loam with slightly acidic with pH (5.6). The data regarding days to 90% curding, canopy area (cm2), leaf number per plant, above ground dry mater (g m-2) (AGDM), curd size (cm2) and curd weight per plant(g), days to curding to harvesting interval, yield, HI and B:C ratio were recorded and analysed using MS Excel and R studio. Significantly higher number of leaves per plant (16.03), bigger average canopy area (5089.93 cm2), higher AGDM (217.91 g m-2), bigger (1563.03 cm2) and heavier curds (1412.44 g) were recorded in 1st Dec. transplanted cauliflower with significantly higher harvest index (68.20). Regarding the sources of nitrogen, all the above parameters were seen better under BCH+ PM but were statistically at par with other nitrogen sources except control. The 1st Dec. planted crop had 4 more days of curding to harvesting interval than 16th Dec. planted one but the difference was not significant. December 1st planted cauliflower yielded 110% more yield and net returns than 16th Dec. planted crop whereas BCH incurred maximum cost (NRs 322145 ha-1) and U and U+PM were the most profitable in terms of B:C ratio (12.77 and 12.96 respectively).Hence, better crop yield and benefit could be obtained by planting the late season cauliflower (var. Snow mystic) at 1st Dec with the use of 100% urea or U+PM as nitrogen source in plains of Nepal having Chitwan like climate.
Keywords: Cauliflower, Bio-char, planting dates, Nitrogen source

INTRODUCTION

Cauliflower (*Brassica oleracea* L. var. Botrytis, 2n=2x=18) is one of the most important commercial winter vegetables grown throughout the world, which belongs to the family Brassicaceae. In, Nepal it can be successfully grown from terai to high hills. Globally, 26.5 million tonnes of cauliflower was produced with a yield of 1,86,937 kg/ha in 2018, led by China & India (FAOSTAT, 2018). In Nepal, cauliflower is one of the highly preferred vegetables cultivated in about 34,967 ha, which shares 14.9 % (550044.8 Mt) of the total vegetable production of the country (Ghimire, Lamsal, Paudel, Khatri, & Bhusal, 2018). It is an annual crop that is propagated by seed & grown in both normal as well as in the offseason with appropriate technology. The white tender head (curd) is consumed as roasted, boiled, fried, steamed, or even raw alone or with other vegetables (Sahito et al., 2018), while the rest part like stalk and leaves are used in animal feeds. Cauliflower is low in fat but rich in carbohydrates, protein, vitamins, minerals, and antioxidants.

Cauliflower can be grown in a wide range of climatic conditions but being a very sensitive crop it needs distinct climatic conditions for its transformation from vegetative to curd initiation and its development (Ray

& Mishra, 2017). The cool moist climate is best for its cultivation and the head doesn't form well in hot weather conditions. Temperature plays an important role in the formation, development & quality of curd (Naik, Babu, & Lakshminarayana, 2016). The high temperature at curd development and maturity period result in low-quality curd (Naik et al., 2016). The optimum time for curd formation is 15.2 oC with an average maximum of 25 oC and a minimum of 8 oC (Naik et al., 2016). Hence proper planning of the planting dates is very important for the optimization of the crop.

Proper sowing and transplanting dates in cauliflower influence all the yield parameters (Naik et al., 2016). Transplanting times differ with the varieties cultivated in particular agro-climatic conditions prevailing in a particular region (Gill H S and Sharma S R, 1996). Cauliflower is grown in early, mid to late and late varieties. Late varieties of cauliflower are cultivated from November to March. Maturity in cauliflower varies with the seasons of years, fall plantings take the longest to mature which is followed by planting in winter and spring (Howe & Waters, 1982).

Cauliflower is a heavy feeder and its productivity depends on the use of balanced fertilizer and there may be considerable loss in the yield if not adequately fertilized (Chatterjee, 1993). N plays an important role in the growth & development of plants (Yoldas, Ceylan, Yagmur, & Mordogan, 2008). A yield of 50 t ha-1 cauliflower removes approximately 200 kg of N, 85 kg P, and 270 kg K (Bashyal, 2013). And their uptake by plant reduce their availability in soil over time after crop harvesting, as those plant used nutrients are not returned into the soil (Fajardo et al., 2016). In order to fulfill the requirement, there is excess use of inorganic fertilizer. But in the long run, it has a detrimental impact on soil health, ecology, and other natural resources which affect soil microorganisms and also human beings (TEKASANGLA & Department, 2015) hence a sustainable approach to nutrient management is a must.

Biochar is a highly stable charcoal-like solid carbon-rich, highly porous organic biomass that is obtained by pyrolysis (direct thermal decomposition of biomass in the absence of oxygen) (Narzari, Bordoloi, Chutia, & Borkotoki, 2015). Biochar application increases the absorption capacity, cation exchange capacity, and pH of the soil (Hagab, Eissa, Abou-Shady, & Abdelmottaleb, 2016) and also helps in retaining water and nutrients in the soil and used by the plants as they grow. Using biochar in soil enhances adoption towards climate change impacts & carbon sequestration purposes due to the recalcitrant nature of biochar (Dahal, Bajracharya, & Merz, 2018). Commercial fertilizer demand is reduced by 8-12% and saved 8-10% of the cost with the co-application of biochar with fertilizers (Li et al., 2017).

In Chitwan, farmers can be encouraged for cauliflower production during winter by increasing the yield which can be achieved through the selection of proper planting time and appropriate sources of nitrogen. Hence, the research is carried out to assess the effect of planting dates and sources of nitrogen on the overall performance and economics of cauliflower (variety snow mystic) at Rampur, Chitwan.

MATERIALS AND METHODS

Site description

The field experiment was conducted at the research block of horticultural farm of Agricultural and Forestry University, Rampur, Chitwan Nepal from 1^{st} Nov 2019 to 4^{th} March 2020. The experimental site is about 256 m above sea level and geo-graphically it is situated at latitude of 27^0 40' N and longitude of 84^0 23' E. The soil samples from the experimental site were collected & analysed in soil lab, where the soil is found to be slightly acidic with soil p^H of 5.6. The soil texture was found to be sandy loam with 4.2% organic matter content. The experimental site lies in the subtropical humid climate belt of Nepal. The weather conditions is sub-humid type with cool winter, hot summer, and distinct rainy season with rainfall of about 2000mm per annum. The weather data during the cropping season of cauliflower was recorded from NASA Power website. (Figure-1)

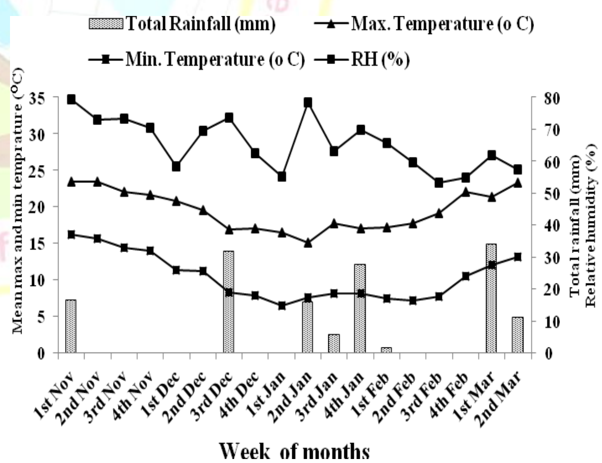

Figure 1. Mean maximum and minimum daily temperature (^oC), relative humidity and Total rainfall (mm) during Nov - 2019 to March 2020, at Rampur, Chitwan, Nepal.

The average maximum temperature of 19.57 ^0C was recorded which ranges from 15.13-23.5 ^0C while average minimum temperature was 10.41 ^{0} C which ranges from 6.45- 16.19 ^0C. The average relative humidity was 65.57% ranging from 53.18-79.49% with total rainfall of 144.53 mm ranging from 0-33.98 mm.

Experimental design and treatments

The experiment was carried out in Split Plot Design, with two factors i.e. two dates of planting, (1st Dec & 16th Dec) as main plot factor and four sources of nitrogen viz. 100% bio-char(BCH), 100% urea(U), 50% urea+ 50% Poultry manure(U+PM) & 50% BCH+ 50% PM(BCH+PM) against control as sub-plot factors and were replicated thrice with 30 experimental units each 9 m^2 size containing 5 rows with 5 plants per row.

Crop management

Seed of Snow Mystic variety of cauliflower were shown on two different dates (Nov 1st & Nov 16th) in the raised nursery beds of 3*1 m in size. And a month old healthy, uniform size & height of cauliflower seedlings were transplanted with the spacing of 60cm* 60cm.

The recommended dose of fertilizer used for the research was 108:92:60 kg N, P_2O_5, K_2O ha^{-1} and P and K were supplied through SSP and MOP. The nitrogen applied from the various sources was applied based on their nitrogen content determined from the laboratory analysis. The laboratory analysis of PM showed 3% N content and cow Urine soaked BCH contain 4% N. Different intercultural operations like weeding, gap filling, earthing up, irrigations, & plant protection measures like using insecticides & fungicides were done according the requirements during the crop growing period. And they were harvested after the curds attained the marketable size.

Sampling and Measurements

The biometrical observations like number of leaves per plant, plant canopy covered (cm^2), days to curd initiation, days to curd harvest, days to curding to harvest interval, weight of marketable curd per plant(g), curd area (cm^2), total (AGDM) above ground dry matter (g/m^2), economical yield($t\ ha^{-1}$), harvest index (HI), and B:C ratio were recorded from randomly selected 5 plants in each plot and average were calculated. Regarding days to curding days, days to 90% curding days were recorded and harvested at horticultural maturity. The fresh weight of leaves, stem and curd were oven dried and expressed in above ground dry matter ($g\ m^{-2}$). The HI was determined by calculating the ratio of dry weight of curd and total dry weight and is expressed in percentage. And the B:C ratio was calculated by dividing the gross return by total cost of cultivation of cauliflower based on the local market price of Chitwan during the experimental period.

Statistical analysis

The observed data were recorded in MS Excel and were subjected to analysis of variance, and Duncan's multiple range test at a level 0.05 (DMRT) for mean separations based on (Gomez & Gomez, 1984). Dependent variables were subjected to analysis of variance using the R Studio for split plot design. Sigma Plot v. 12 was used for the graphical representation.

RESULTS AND DISCUSSION

The growth of cauliflower in terms of leaf production, canopy covered, the major yield attributes, yield and economics of cauliflower as influenced by the date of planting and source of nitrogen is presented and discussed below:

The number of leaves per plant and the canopy area covered by cauliflower were significantly influenced by dates of planting and sources of nitrogen. The average leaf number per plant 8-14.6 and the average canopy covered by each plant increased from 1436.72cm^2 to 4849.44cm^2 respectively from 30 days after transplanting (DAT) to 75 DAT. The average leaf number per plant was found significantly different only at 60 and 75 DAT. At 60 DAT, the leaf numbers of cauliflower transplanted on Dec 1st (12.56) were statistically higher than that on Dec 16th (11.56). And similar trend was also followed for 75 DAT. Similar findings also reported by (Ara, Kaisar, Khalequzzaman, Kohinoor, & Ahamed, 2009) with 19.53 leaves with early planting. More number of leaves in early planting may be due to the warmer temperature which results in more vegetative growth (Islam, Datta, & Chatterjee, 2016); (Kumar, P.T., Babu, S.D., Aipe, K.C., 2002).Whereas all the sources of nitrogen were statistically similar in terms of leaf production and were statistically higher over control for both 60 and 75 DAT. Increased leaf number and plant spread might be due to nitrogen which contribute an increase in leaf buds (SANGEETA SHREE*, 2014).

The average canopy area per plant was significantly influenced by the date of planting and sources of nitrogen. December 1st planted cauliflower plant covered significantly higher canopy area at all dates of observations except than December 16th except for 75 DAT where the difference in canopy area was not found significant. Regarding the sources of nitrogen, at 30 DAT and 60 DAT, U+PM, BCH, BCH+PM had significantly higher and similar canopy coverage. The average canopy coverage of cauliflower per plant at 75 DAT was statistically similar in U+PM, BCH+ PM, Urea whereas BCH had significantly lower canopy coverage than these sources of Nitrogen. Oyedeji et al., 2014 also recorded that plant growth using inorganic (NPK) and PM increases soil fertility where inorganic perform better.

Yield attributes and yield

Days to curding & harvesting

The average number of days at which 90% of the plant started curd development was neither significantly affected by the planting dates nor the sources of nitrogen and average days at which 90% of plants showed curd development was 68.83. The crop was ready for harvesting at average of 80.48 days and this was significantly different between the plants planted at different dates. Dec 16th planted cauliflower were ready for harvest for about six days earlier than Dec 1st planted crop but the days to harvesting was not significantly influenced by the sources of nitrogen. The longer crop duration in early planting might be due to higher temperature in early growth stage resulting in more vegetative growth period than in later planting and was in accordance of the explanations of (Islam et al., 2016).According to Ara, N., Kaisar, M.O., Khalequzzaman, K.M., Kohinoor, H., Ahamed, (2009), quick curd initiation on late planting was due to the exposure of plant to favourable climate for shorter period for vegetative growth and the subsequent higher temperature hastened the curd initiation and hence reached the harvesting stage faster than early planted cauliflower.

Curd area, fresh curd weight at harvest and above ground dry matter (AGDM)

The average curd area, average fresh weight of curd, average AGDM production, and yield were significantly influenced by the dates of planting and sources of nitrogen. The average total AGDM production, average curd area, average curd fresh weight was significantly 99.5%, 93.41% and 111% more in Dec 1st planted cauliflower than Dec 16th planted ones. All these parameters were significantly higher over control but statistically at par with each other under all sources of nitrogen. According to Almaz, Halim, & Martini, 2017 chemical fertilizer could be substituted by 50 % using PM without reducing crop yield. Malick (1994) also reported highest curd area with early plantation and Uddin, M.R., Dey, S., Islam, M.R., (2011) stated that bigger sized curd in early planting was due to low temperature during vegetative growth. Higher dry matter production under early planting might be due to more photosynthate accumulation due to longer crop period. Hassan, (2019) also reported that curd diameter as well as weight gradually decrease with delay in planting. This differences might be due to the variation in the growth environment and climatic parameters during the growth period as stated by period (Islam et al., 2016). Also, the yield in production of cauliflower increased by 14.6 t/ha by using biochar (Khadka, 2017). Kumar, Das, Prasad, & Kumar, 2013 recorded that co-application of organic and inorganic fertilizers significantly increased the yield in broccoli over inorganic fertilizers alone.

Table 1: Average number of leaves and average canopy area (cm^2) per plant as influenced by the planting dates and sources of nitrogen at Rampur, Chitwan during 2019-2020

Treatments	30 DAT		45 DAT		60 DAT		75 DAT	
	canopy	Leaf No.	canopy	Leaf No.	canopy	Leaf No.	canopy	Leaf No
Date of transplanting								
Dec 1st	1895.37a	7.64	3631.10a	9.81	4710.87a	12.56a	5089.93	16.03a
Dec 16th	978.08b	8.36	2043.81b	9.95	3680.41b	11.56b	4608.95	13.69b
SEM (±)	458.65	0.36	793.65	0.067	515.23	0.5	240.49	1.17
LSD (=0.05)	152.38	NS	104.01	NS	489.05	0.263	NS	1.18
CV, %	6.8	7.5	2.3	21.5	7.4	1.4	7.7	5.1
Nitrogen sources								
Control	1163.07c	7.77	2215.87c	9.80	2748.08c	11.17b	2936.53c	13.50b
BCH	1552.09a	8.40	2994.03a	9.83	4480.67ab	12.37a	5000.03b	15.03a
Urea	1349.30b	7.87	2867.22b	10.30	4287.38b	12.33a	5124.33ab	15.20a
U+ PM	1601.15a	7.93	3203.64a	9.57	5098.93a	12.30a	5772.95a	15.37a
BCH+ PM	1517.99a	8.03	2906.54b	9.90	4363.15ab	12.13a	5413.33ab	15.20a
SEM (±)	80.46	0.109	165.93	0.12	389.17	0.23	496.40	0.34
LSD (=0.05)	101.65	NS	158.64	NS	737.07	0.82	693.43	0.93
CV, %	5.8	6.2	4.6	5.9	14.4	5.5	11.7	5.1
Grand mean	1436.72	8	2837.46	9.88	4195.64	12.06	4849.44	14.86

Note: BCH, 100% Biochar; Urea, 100% Urea; BCH+ PM, 50% Biochar +50% Poultry Manure; U+PM, 50% Urea + 50% Poultry Manure

Yield and Harvest Index (HI)

The average yield of cauliflower and the HI was also found significantly influenced by the date of planting and sources of nitrogen. Yield and HI were significantly (111%, 17.31% respectively) more under December 1st planting. All the sources of nitrogen were similar in terms of yield and HI and were superior over control. This difference might be due to lowering down of average maximum and minimum temperature in delay planting & in early planting, crop remain in field for long period accumulating more photosynthates which result in higher yield and HI (Gautam, B.P., Shadeque, A., Saikia, 1998) and (Hassan, 2019). And in presence of organic fertilizer, inorganic N was found more effective in curd yield of cauliflower (Gamel, 2008). Khadka (2017) found 14.6 t ha^{-1} yield increment of cauliflower through the biochar application.

Table 2: Phenology, yield attributes and yield of cauliflower as influenced by the planting dates and sources of nitrogen at Rampur, Chitwan, 2019-2020

Treatment	Days to Curding	Days to harvesting	Curd Area (cm²)	Curd Fresh Weight (g)	Total AGDM (g m-2)	Yield (t ha-1)	Harvest Index
Date of transplanting							
Dec 1st	69.40	83.20a	1563.03a	1412.44a	83.20a	39.24a	68.20a
Dec 16th	67.87	77.76b	808.12b	669.68b	77.76b	18.60b	50.89b
SEM	0.77	2.72	377.46	371.38	2.72	10.32	8.65
LSD (=0.05)	NS	1.49	378.20	339.50	1.49	9.45	8.06
CV, %	9.7	1.2	20.3	20.8	1.2	20.8	8.6
Nitrogen sources							
Control	69.33	80.20	564.27b	434.63b	80.20	12.07b	57.34b
BCH	66.67	80.17	1253.33a	1129.97a	80.17	31.39a	62.19a
U	70.50	80.90	1332.87a	1181.13a	80.90	32.81a	58.60ab
U+ PM	68.33	80.47	1346.35a	1205.17a	80.47	33.48a	59.002ab
BCH+ PM	68.33	80.67	1431.07a	1254.4a	80.67	34.86a	60.60ab
SEm (±)	0.63	0.14	157.87	152.93	0.14	4.25	0.84
LSD (=0.05)	NS	NS	328.15	322.06	NS	8.96	3.89
CV, %	4	0.8	22.6	25.3	0.8	25.3	5.3
Grand mean	68.63	80.48	1185.58	1041.06	80.48	28.92	59.54

Note: BCH, 100% Biochar; Urea, 100% Urea; BCH+ PM, 50% Biochar +50% Poultry Manure; U+PM, 50% Urea + 50% Poultry Manure

Table 3: Total cost production, Gross and net return (NRs.ha^{-1}) and B:C ratio of cauliflower as influenced by the dates of planting and sources of nitrogen at Rampur, Chitwan during 2019-2020

Treatment	Cost (NRs.ha-1)	Gross Return (NRs.ha-1)	Net return (NRs.ha-1)	B:C ratio
Dates of planting				
Dec 1st	150349.8	1177294.2a	1026944.4a	10.41a
Dec 16th	150349.8	558111.4b	407761.6b	5.11b
SEM (±)		309591.4	309591.4	2.65
LSD (=0.05)		283413.7	283413.7	1.05
CV, %		20.8	25.2	8.7
Sources of Nitrogen				
Control	72145e	362223.4b	290078.4c	5.02b
BCH	322145a	941714.2a	619569.2b	2.92c
Urea	77059d	984356.5a	907297.5a	12.77a
U+ PM	77700c	1004386a	926686a	12.93a
BCH+ PM	202700b	1045833.7a	843133.7ab	5.16b
SEM (±)	49507.4	127477.1	119967.8	2.12
LSD (=0.05)	2.3	268726.7	268726.7	1.91
CV, %	0	25.3	30.6	20.1
Grand mean	150349.8	867702.8	717353	7.76

Economic Analysis

The total cost of production, gross and net returns and B:C ratio of cauliflower as influenced by the dates of planting and sources of nitrogen is as shown in Table 3. The average cost of cultivation was NRs. 150349.8 and highest cost was incurred in BCH treatment followed by BCH+PM, U+PM. The gross return did not vary among the sources of nitrogen but were significantly higher than control and December 1st planted cauliflower gave higher gross return. The December 1st planted cauliflower gave NRs. 619182.8ha^{-1} more net returns and had twice B:C ratio than the later planted one. The net return under Urea, U+ PM, BCH+ PM were statistically similar but the returns under BCH was lower because of the higher cost incurred for the biochar preparation and urine treatment. Hence, it also had smaller B:C ratio compared to other nitrogen sources.

Linear and significant relationship was seen between AGDM and yield and curd area and yield with high correlation coefficient and coefficient of determination as shown in figure 2.

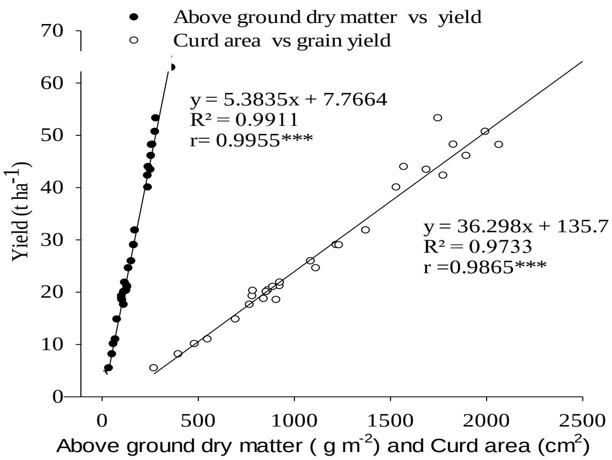

Figure 2: Relationship between above ground dry matter production and curd area with grain yield

CONCLUSION

December 1st was the most appropriate date of planting of late season variety of cauliflower and the supplement of nitrogen from any of the considered sources was equally effective. The profit could be doubled by planting the seedlings at 1st December.

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