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Effect of Seedling Density on Growth Attributes of Cauliflower variety Kathmandu Local in Nursery Bed

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***Abstract*— *Nursery management including optimum seedling density is an important factor for better crop performance. A study was carried out to examine the effect of seedling density on growth attributes of cauliflower seedlings cv. Kathmandu local in the field of Lamjung Campus in Oct., 2018. Experiment consists of four treatments which were replicated five times and laid out in RCBD. Seed spacing treatments viz. 0.5cm x 1.0cm, 1.0cm x 1.0cm, 1.5cm x 1.5cm and 2.0cm x 2.0cm were maintained in a raised nursery beds. Field germination percentage was recorded up to 60% at fourth day after sowing (DAS) whereas in lab it was up to 74%. Above and below ground seedling biomass, unfold leaves area, number of true leaves, plant height and root length were recorded at 23 DAS by destructive method. ImageJ package was used for leaf area measurement. Data were tabulated in MS Excel and analyzed by GenStat. Root length (4.85cm) was significantly higher in spacing of 2cm x 2cm which was at par with 1.5cm x 1.5cm whereas lower in 0.5cm x 1.0cm. Significantly maximum value for fresh weight of root (0.045gm), fresh weight of shoot (0.91gm), dry weight of shoot (0.11gm) and dry matter percentage (12%) was observed in 1.5cm x 1.5cm spacing. Seedlings greater than 1.5cm to 2cm spacing performed better than closer spacing in most of the variable of interests, however, there was no significant differences observed in number of true leaves, leaf area and plant height. A trial with wider spacing considering seedling health is recommended.*

***Keywords*— *Competition, Destructive sampling, Germination, Seedling health, Seedling quality*.**

I. INTRODUCTION

Cauliflower (*Brassica oleraceae* L.var) *Botrytis* is a crop that is first raised in nursery and then transferred to main filed. Nursery is a place where plants are grown, carefully nurtured and sold out or transplanted in another field. Success of any crop production system depends on the kind of seed we sow which is true with seedlings and its density. Optimal plant density can be achieved by establishing appropriate distances between rows as well as in rows of plants. Plant spacing is an important agronomic attribute as it effects on light interception during photosynthesis which is energy manufacturing medium using green parts of the plant (Donald, 1963). It affects photosphere and rhizosphere exploitation by plants especially when spacing is limited and the plants suffers clustering together. Good plant spacing maintains right plant density, which is the number of plants, allowed on a given unit of land for optimum yield (obi, 1999). Like other factors that affect per unit area production such as nutrition, cultivar, growing system and soil fertility, plant density has its significance (Agarwal *et al*., 2007). Planting distance did not only influence the plant population and light utilization efficiency, but also affected the inter-plant competition for water and nutrients that eventually affect the plant growth. Lesser the inter-plant competition the higher the plant growth (In Johu *et al.*, 2002)

Not all seeds are developed into seedling in nursery. Small seeds undergo erratic germination, insect pest attack, moisture deficiency in main field. So it needs to be raised in nursery first and then transplanted to the field. Seeds. A healthy seedling is a basis for healthy crop. So if the seedlings are strong and vigorous it can withstand harsh environmental condition in the field. But. But in nursery also, due to higher plant density, seedlings undergo various fungal attacks as damping off, collar rot, etc. Seedlings raised in high density, high humidity and high temperature allows disease development mostly damping off. When plants are older they become more resistant to damping off and control measures are unnecessary (Pokhrel, 2012). Use of optimum plant density per unit area encourages plants to grow well both in the upper ground and underground parts through better utilization of solar radiations and nutrients (Bozorgi *et al*., 2011). The wider row spacing may be preferred as there will be airflow through the crop, reducing disease pressure (Ahamad *et al*., 2003). But, Farmers use self-taught technology for nursery management without knowledge of optimum seedling density (Bharathi and Ravishankar, 2018). So the necessity of research concerning seedling density in nursery is felt in majority of small seeded vegetables. Thus a research was conducted to study the effect of seedling density on growth attributes of cauliflower and also to find the optimum sowing distance for production of quality seedlings.

II. MATERIALS AND METHODS

2.1. Location of Experiment Site:

The experiment was conducted on the horticulture laboratory and field of IAAS lamjung Campus. This place has humid sub-tropical with cold winter, hot summer and distinct rainy season. Germination test of seeds were carried out in lab during September and field experiment during October, 2018. Geographically, lamjung is located as: 28˚12ʹ 35.7ʹN latitude and 84˚21ʹ 49.7ʹE longitude with an elevation of 625 masl.

2.2. Germination Test (GT) in Lab

Kathmandu Local, a mid- season variety of cauliflower was collected from nearest agrovet. Observations on different seed parameters such as 1000 seed weight, seed size, color, seed diameter and seed purity% was done and subjected for germination test. 50 seeds were taken in two petri-plates, each containing 25 seeds and observed in germinator for a week during October, 2018. Adequate moisture, light of 12 hours followed by alternate dark of 12 hours, temperature of 32˚C was maintained inside germinator. Seeds were kept there for a week. At 24 hours interval the tray was taken out for germination count. The petri-dishes were checked 2 times each day for necessary rehydration to maintain moisture and possible mould growth. Germination percentage was calculated by using formula;

$$GP = (\sum ni \div N) \times 100\%$$

Where, ni= number of seed germinated in the sample in ith day or time observation

N= number of seeds taken in sample

2.3. Field Experiment

The research was carried out in Randomized Complete Block Design (RCBD) with four treatments replicated five times. Effect of spacing on different parameters of seedling growth cauliflower was studied.

2.3.1 Treatment Setting

Table 1: Details of the treatments used in the experiment

Treatments	Spacing (plant to plant and row to row)
T1	0.5cm x 0.5cm
T2	1.0cm x1.0 cm
T3	1.5cm x 1.5cm
T4	2cm x 2cm

2.3.2. Field Preparation and Seed Sowing

Raised bed with 15cm height and 1.687m^2 area was prepared using spade and tilled repeatedly in order to prepare fine tilth. Soil was drenched with 5g/l SAAF solution and covered with white transparent plastic for about 3 days. Temperature was measured up to 50℃ with digital thermometer. At the day of sowing required amount of fertilizers (urea, DAP, MOP and vermicompost) were mixed well and fine bed was prepared. Seeds of Kathmandu Local was used as seed material. Line sowing was done using thread for separation between two rows such that 15 seeds were accommodated in a single row with different spacing treatments. Seeds were covered from above with the mixture of sand and vermi-compost in the ratio of 1:1. Straw mulching was done in order to protect the seeds from displacement and impact of water drops during irrigation. Mulching was removed after germination of all seeds i.e. 5th DAS.

2.3.3. Intercultural Operation

Cypermethrin was sprayed @2ml/L in order to protect from insects and pests after 10 days of sowing. Similarly, the seedlings were drenched with 5g/ml of SAAF solution to protect from damping off after 13 days of sowing. The solution was sprayed using rose can uniformly. The bed was irrigated with tap water twice a day on daily basis. Similarly weeding was performed by pinching as pulling of roots would disturb neighboring seedlings of the nursery.

2.3.4. Sample Collection and Data Recording

Five samples were collected from each replication of different treatments at 23 DAS. Destructive sampling method was done for further study and measurements.

1. **Number of true leaves (NTL):** Numbers of true leaves were counted on the day of 50% emergence. Only unfolded leaves were counted.
2. **Plant Height (PH):** Heights of the seedlings were measured using rurer and was measured above collar region to the growing tip.
3. **Leaf area (LA):** leaf area was measured *via* imageJ software that gives leaf area after clicking photographs and inserting into the system.
4. **Root length (RL):** Root length was measured using rural below the collar region.
5. **Fresh weight of shoot (FWS):** fresh weight of shoot was measured using an electronic weighing balance after packing inside the envelope. It was calculated as;

FWS = total weight of shoot and envelope using – weight of envelope

6. **Fresh weight of root (FWR):** fresh weight of root was measured using weighing balance after packing inside the envelope. It was calculated as

FWR = total weight of Root and envelope – weight of envelope

7. **Dry matter percentage (DM %):** It is the amount of assimilates accumulated by the plants. The sample was dried for about 48 hours at 65℃ embedded in an envelope. Then it was calculated by using the formula,

DM% = (weight of dry sample ÷ weight of fresh sample) × 100%

2.4. Data tabulation and analysis

Data were tabulated using MS Excel and analyzed through Genstat 15 ed. Mean values of all the recorded characters were evaluated and analysis of variance was performed by 'F' (variance ratio) test. Significance of the difference among the treatments of means was estimated by Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and gomez, 1984).

III. RESULT AND DISCUSSION

3.1. Laboratory Resultab experiment showed result of different parameters of seed as in table 2.

Seed germination test was used to determine the seedling density in nursery.

Table 2: Characteristics of seeds observed in lab of IAAS, Lamjung, 2018

Seed parameters	Result
Seed color	Reddish brown
Seed shape	Oval to round
Seed diameter	1.54 mm
Physical purity	96%
1000 seed weight	2.92 g
Germination	74%

3.2. Effect of Different Treatments on Plant height, Root length, Number of true leaves and Root fresh weight of Cauliflower Seedling

Plant height, number of true leaves and leaf area were indifferent to spacing treatments whereas highly significant result was found with root length. Maximum value were found in wider spacing as compared to closer spacing as represented by table 2.

Table 3: Effect of spacing on plant height, root length, number of true leaves and total leaf area of cauliflower seedlings in Nursery bed in Lamjung, 2018

Treatments	PH (cm)	RL (cm)	NTL	LA (cm^2)
T1(0.5cmx0.5cm)	7.004	3.372^{b}	**2**	6.83
T2(1.0cmx1.0cm)	6.452	3.546^{b}	2	9.19
T3(1.5cmx1.5cm)	7.968	4.655^{a}	3	12.89
T4 (2cm x 2cm)	7.028	4.850 a	2	11.40

Grand mean	7.11	4.11	2	10.07
F value	0.137	<.001	0.069	0.141
level of significance	NS	**	NS	NS
LSD	1.296	0.896	0.462	5.494
cv%	13.2	11.2	14.3	39.6

****: highly significant at p<0.01, *: significant, NS= non-significant, means in column followed by same letters (s) are not significantly different**

3.2.1. Plant height, Number of true leaves and Leaf area

Plant height, number of true leaves and leaf area exhibit statistically similar result for the various treatments. This result was supported by study of Ahamad *et al*., (2007) where he found no effect of spacing on number of leaves per plant of forage sorghum. Similarly, field experiment conducted with different spacing treatments on lettuce showed non-significant result for plant height (Zemichael *et al*., 2017). In the contrary, Mujeeb-ur-Rahman *et al*., (2007) reported tallest plant height in wider spacing and was due to better rooting distance that reduces competition between plants for growth factors such as light, water and nutrients, while narrowing planting distance will raise inter plant competition. This fulfillment could increase the leaf width of the plant. Wider planting distance produced largest leaf width. It resulted in the photosynthesis working well that increased the formation of dry materials and augmented the cell size causing increase in plant height (Lihiang and Lumingkewas, 2017. Again in contradiction to this finding, maximum plant height was obtained with highest plant density (11plants per m2) while least value was obtained in 7 plants per m2 (Sharif and Namvar, 2016). He also reported that increase in plant height due to greater plant density may be attributed to better vegetative growth that resulted in increased mutual shading and intermodal extension.Opposite result was found with lettuce cultivar planted in closer spacing. Plant height, leaf area and leaf numbers increased with a decrease in plant population (Maboko and Steyn, 2009).

3.2.2. Root length

The effect of different sowing distance showed highly significant difference in root length of cauliflower seedlings. Highest root length (4.85 cm) was observed for spacing with 2cm which was statistically at par with spacing of 1.5 cm. similarly, smaller root length was observed in 0.5 cm (3.37cm) which was statistically at par with spacing of 1 cm. (Minami and Sirkar, 1998) revealed same results regarding root length i.e. by increasing plant to plant spacing, increase in root length will occur. Similar result was found by (Khan *et al*, 2016) in radish. The wider spacing provided more chance for development of root by proper utilization of assimilates thereby minimizing loss which would be spent during shoot elongation in narrow spacing and thus resulted in maximum root growth and weight (Hussain *et al.*, 2008). Similar result was found in cauliflower which was due to less competition among roots of plants for resources that lead to extension of roots than closer spacing (Farzana *et al*., 2016). In contrary, root length was found maximum in narrow spacing of rice which was due to elongation of root tip in search of moisture in deeper layer of soil (Asmamaw, 2014).

3.3. Effect of Different Treatments on Fresh Weight, Dry Weight and Dry Matter Percentage of Shoot of Cauliflower Seedlings.

Fresh weight of root, fresh weight of shoot, dry weight of shoot and dry matter content of seedlings showed better result in wider spacing i.e 1.5 cm as represented by table 3.

Table 4: Effect of seedling spacing on fresh weight of root and shoot, dry weight of shoot, dry matter % of cauliflower in lamjung, 2018

Treatments	FWR (g)	FWS (g)	DWS	DM %
T1(0.5cmx0.5cm)	0.0206[b]	0.3759[c]	0.03039[c]	8.21[b]
T2(1.0cmx1.0cm)	0.0252[b]	0.6166[bc]	0.0690[b]	11.55[ab]
T3(1.5cmx1.5cm)	0.0452[a]	0.9048[a]	0.1123[a]	12.52[a]
T4 (2cm x 2cm)	0.0404[a]	0.7649[ab]	0.0757[b]	10.49[ab]
Grand mean	0.0329	0.6660	0.0720	10.70
F value	0.011	0.004	<.001	0.041
level of significance	*	*	**	*
LSD	0.01502	0.2718	0.0254	3.243
cv%	33.2	27.4	25.6	20%

****: significant at p<0.01, *: significant at p<0.05: NS= non-significant, means in column followed by same letter(s) are not significantly different**

3.3.1. Fresh weight of shoot

Significantly higher fresh weight of shoot (0.90g) was obtained in 1.5 cm which was statistically at par with 2cm. lowest fresh weight of shoot (0.3759g) was obtained in 0.5 cm spacing which was statistically at par with 1cm spacing. Similar trend of result was reported by (Islam *et al*, 2014) in spanich. In wider spacing, plants received more solar radiation, optimum moisture and are more photo-synthetically efficient than closely spaced one (Morrison *et al*., 1990).

3.3.2. Fresh weight of root

The effect of different spacing was found to be significant for fresh weight of root. Highest result (4.85cm) was obtained with spacing of 1.5 x1.5 cm^2 which was statistically at par with 2x2 cm^2 spacing. Similarly, lowest fresh weight (3.372 cm) was obtained with 0.5x0.5 cm^2 spacing which was statistically at par with 1x1cm^2 spacing. Similar result was found by (Khan *et al*, 2016) in radish. The wider spacing provided more chance for development of root by proper utilization of assimilates thereby minimizing loss which would be spent during shoot elongation in narrow spacing and thus resulted in maximum root growth and weight. (Hussain *et al.*, 2008).

3.3.3. Dry weight of shoot

Dry weight of shoot was found to be highly significant and maximum value (0.1123g) was obtained in 1.5cm and lowest (0.039g) in 0.5 cm. The better availability of inputs under wider geometry might have helped seedlings to grow profusely resulting rapid initiation of leaves and their expansion, thereby giving higher leaf area, ultimately resulting in higher rate of photosynthesis. Besides this, smaller number of plants per unit area under wider geometry might have also provided favorable environment for root development below ground. This might have led to adequate supply of nutrients from root to shoot, result in higher biomass accumulation per plant. The result is supported by (Kaushik and Shaktawat, 2005). In contrary, dry matter production decreased with increased plant population due to mutual shading of leaves, increased respiratory losses, resulting decreased net photosynthesis per unit leaf area (Pushpa *et al*., 2013).

3.3.4. Dry matter of shoot

Spacing treatments showed significant result for dry matter content of shoot. Highest dry matter content (12.52%) was found with spacing of 1.5 cm. similarly lowest value (8.21%) was obtained with spacing of 0.5 cm. Similar trend of results were reported in spanich by (islam et al., 2014). Decrease in plant density increases area for better absorption of nutrients, moisture and lights facilitating efficient photosynthesis (Mujeeb-ur-Rahman *et al*., 2007). Higher dry matter accumulation in leaf increased total dry matter content in plants. Greater accumulations found in stem was due to increased photosynthesis and greater translocation of assimilates from source to sink in presence of adequate resources (Guggari, 2002).

IV. CONCLUSION

Slender and poor quality seedlings were obtained in narrow spacing while reverse happened in optimum spacing. Denser plant population lead to increased fungal diseases while optimum spacing gave robust seedlings. Among four spacing treatments, 1.5 cm x 1.5 cm spacing proved better result in all aspects.

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