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Effect of Nitrogen and Spacing on Quality and Economics of Common Onion (*Allium cepa* L.) cv Prema 178 under Manipur Condition

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ABSTRACT

The field experiment was conducted to determine the effect of nitrogen and spacing on quality and economics of common onion (*Allium cepa* L.) cv Prema 178 under Manipur condition in Factorial Randomized Block Design (FRBD) constituting four levels of nitrogen (0 kg N/ha or control, 50 kg N/ha, 100 kg N/ha and 150 kg N/ha) and three levels of spacing (10 cm × 10 cm, 15 cm × 10 cm and 20 cm × 10 cm) with 12 treatment combinations replicated thrice. The results of the experiment showed that TSS was maximum individually at lower nitrogen dose of 50 kg N/ha and closer spacing of 10 cm × 10 cm, while higher nitrogen dose of 150 kg N/ha and wider spacing of 20 cm × 10 cm individually produced maximum dry matter percent and harvest index. Interaction of nitrogen and spacing had no significance on TSS, dry matter content and harvest index; however, interaction of higher nitrogen dose of 150 kg N/ha and closer spacing of 10 cm × 10 cm resulted in maximum economic returns and maximum benefit-cost ratio.

Keywords Nitrogen, Spacing, Quality, Economics, Common onion.

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INTRODUCTION

Onion (*Allium cepa* L.), a bulbous biennial crop belonging to the genus *Allium* and family Alliaceae is an important culinary item used in vegetable preparation and as a condiment for seasoning foods. It is a cool season crop grown under a wide range of climatic conditions like tropical and subtropical, and it depends on temperature and day length for development of bulb (Thamburaj and Singh 2001). The pungency of onion is due to "allyl propyl disulphide", a volatile oil which is formed by enzymatic reaction only when tissues are damaged and it is higher just before neck fall. Red color onions are more pungent compared to brown, yellow and white onions (Dhaliwal 2017).

Onion bulb is rich in carbohydrates, protein, fiber, vitamins and other minerals. Vitamin A (2 IU), vitamin B6 (0.12 mg), vitamin E (0.02 mg), magnesium (10 mg), potassium (146 mg) are also recorded per 100 g of onion bulbs (Pareek *et al*. 2017). Onion bulb has been reported to have many medicinal values like anti-inflammatory, antiseptic, diuretic, hypoglycaemic and carminative properties (Sampath Kumar *et al*. 2010) and are considered as one of the few vegetables that helps in reducing heart disease risk (Jain *et al*. 2019).

Even though onion has a major contribution in the Indian economy as well as health benefits, there is lesser adoption of improved technology and poor agronomic management practices. Onion, being a shallow rooted crop, requires proper management of fertilizers to absorb the immobile nutrients of the soil (Brewster 1994). Nitrogen is required for bulb development in onions and it is responsible for its characteristic flavor, pungency and quality (Randle 2000), but increase in nitrogen doses resulted to reduced bulb quality and plant mortality (Singh *et al.* 1994) and decrease in dry matter percent (Karsanbhai 2003). However, higher levels of nitrogen beyond 125 kg/ha had adverse effect on biochemical constituents in bulb storage quality (Pawar 1995).

Determining an optimum plant spacing for each agro-ecological region helps to increase the bulb production and productivity of onion (Gupta *et al.* 1994). Dry matter content, TSS content (%) and other quality characters increased significantly with decrease in plant spacing (Ushakumari *et al.* 2001, Ganie and Solanki 2010). Furthermore, the combined treatment of optimum levels of nitrogen and spacing resulted in maximum Cost Benefit Ratio with better quality of onion (Kumari and Kumar 2017). Therefore, optimizing proper nitrogen levels and spacing can be adopted to produce higher quality of onion bulbs and obtain higher economic returns with higher benefit-cost ratio.

MATERIALS AND METHODS

The experiment was conducted during *rabi* season of 2020-21 at the Horticultural Experimental field, Department of Horticulture, College of Agriculture, Central Agricultural University, Imphal using the onion variety "Prema 178". The study was carried out in a net experimental area of 43.2 m^2 and plot size of 1.2 m^2 in Factorial Randomized Block Design (FRBD) constituting four levels of nitrogen (0 kg N/ha or control, 50 kg N/ha, 100 kg N/ha and 150 kg N/ha) and three levels of spacing (10 cm × 10 cm, 15 cm × 10 cm and 20 cm × 10 cm) with 12 treatment combinations replicated thrice. The physio-chemical status of the soil was slightly acidic, clay in texture with medium in available nitrogen, phosphorus, potassium and organic carbon. Data on Total Soluble Solids (^{0}Brix) and Dry matter (%) of bulb and Harvest Index (%) were recorded at harvest and statistically analyzed with the significance of the test (F-test) and critical difference (CD) for each treatment read at 0.05 probabilities (Sunderaraj *et al.* 1972).

Total soluble solids (^{0} Brix): The total soluble solids (TSS) of onion bulb in each treatment were found out through a hand refractometer and expressed as degree brix (^{0}Brix).

Dry matter (%) of bulb: The dry matter percent of bulb at harvest was calculated using the following formula :

$$\text{Dry matter (\%)} = \frac{\text{Dry weight of bulb (g)}}{\text{Fresh weight of bulb (g)}} \times 100$$

Harvest index (%): Harvest index is calculated at harvest by using the following formula.

$$\text{Harvest index (\%)} = \frac{\text{Dry mass of economic yield (g)}}{\text{Dry mass of biological yield (g)}} \times 100$$

Economics: Additional cost involved and returns obtained with seed material, organic manures, chemical fertilizers and all the applied inputs during experimentation were worked out based on the market rate on a per hectare basis. Based on the prevailing prices of inputs at the time of their usage and the market price of the produce at the time of their sale, the gross return, net return and benefit-cost ratio were worked out using the following formula.

Cost of cultivation (Rs/ha): It was calculated on a per hectare basis for each treatment by taking into accounts the inputs, labor and operational cost.

Gross returns (Rs/ha): The total monetary value of the economic produce obtained from the crops was obtained based on local market prices of the product and expressed on a unit hectare.

Gross income (Rs/ha) = Market value of total bulb yield

Net returns (Rs/ha): Net return was calculated by deducting the total cost of cultivation from gross return.

Net return (Rs/ha) = Gross returns (Rs/ha) – Total cost of cultivation (Rs/ha)

Benefit-cost ratio (B:C): Benefit-cost (B:C) ratio was computed based on the following formula.

$$\text{Benefit-cost ratio (B:C)} = \frac{\text{Net returns (Rs/ha)}}{\text{Total cost of cultivation (Rs/ha)}}$$

RESULTS AND DISCUSSION

Effect of nitrogen and spacing on total soluble solids (^{0}Brix) of common onion at harvest

The total soluble solids (TSS) of common onion was significantly affected by nitrogen. According to Table 1, it was found that lower nitrogen dose N_2 - 50 kg N/ha recorded maximum TSS (12.28 ^{0}Brix) of common onion at harvest, and this might be due to the production of smaller sized bulbs in minimum nitrogen supply to plants. Smaller bulbs have smaller surface areas, and thus they have lower respiration and transpiration losses, resulting in higher TSS (Vidya *et al*. 2013). Similar result was also reported in previous findings (Pawar 1995).

Likewise, closer spacing S_1 - 10 cm x 10 cm exhibited maximum TSS (12.53 ^{0}Brix) of common onion at harvest and it showed a significant effect on TSS (Table 1).). Smaller bulbs produced at closer

Table 1. Effect of nitrogen and spacing on total soluble solids, dry matter (%) and harvest index of common onion.

Treatments		Total soluble solids (^{0}Brix)	Dry matter (%) of bulb	Harvest index (%)
0 kg N/ha (control)	N_1	11.35	11.69	75.44
50 kg N/ha	N_2	12.28	12.10	79.58
100 kg N/ha	N_3	11.89	12.44	83.24
150 kg N/ha	N_4	11.76	12.46	85.99
	SEm (±)	0.17	0.11	0.99
	CD (0.05)	0.50	0.33	2.89
10 cm×10 cm	S_1	12.53	11.93	80.35
15 cm×10 cm	S_2	11.80	12.15	81.22
20 cm×10 cm	S_3	11.13	12.43	81.62
	SEm (±)	0.15	0.10	0.85
	CD (0.05)	0.43	0.29	NS
	N_1S_1	11.92	11.47	74.54
	N1S_2	11.30	11.64	74.94
	N_1S_3	10.83	11.96	76.84
	N_2S_1	12.94	11.93	78.84
	N_2S_2	12.27	12.09	79.78
Treatment	N_2S_3	11.62	12.27	80.11
combinations	N_3S_1	12.66	12.15	82.20
	N_3S_2	11.96	12.36	84.31
	N_3S_3	11.07	12.81	83.22
	N_4S_1	12.60	12.18	85.81
	N_4S_2	11.66	12.53	85.85
	N_4S_3	11.01	12.68	86.31
	SEm (±)	0.29	0.20	1.71
	CD (0.05)	0.86	0.58	5.01
Interaction effect (N x S)		NS	NS	NS

SEm (±): Standard error of mean, CD (0.05): Critical difference at 5% level of significance NS: Non-significant.

spacing have a higher TSS than larger bulbs produced at wider spacing, which might be because of larger bulbs having higher water content and fewer carbohydrates. The result was similar to the conclusion of previous findings (Ganie and Solanki 2010).

Among the interaction of nitrogen and spacing, N_2S_1 (50 kg N/ha and 10 cm × 10 cm spacing) recorded the highest TSS (12.94 ^{0}Brix), while lowest TSS (10.83 ^{0}Brix) was observed at N_1S_3 (control-0 kg N/ha and 20 cm × 10 cm spacing). However, there was no significant effect of interaction of nitrogen and spacing on the total soluble solids (TSS) of common onion at harvest.

Effect of nitrogen and spacing on dry matter (%) of common onion bulb at harvest

Data in Table 1 showed that dry matter percentage of the onion bulbs at harvest was significantly influenced by nitrogen and maximum dry matter content was recorded at harvest in higher nitrogen dose N4 - 150 kg N/ha (12.46%). The reason might be because of higher nitrogen supply in plants which increased the fresh and dry weight of onion bulbs at harvest. The result was in accordance with the previous findings of (Hiray 2001, Dilruba *et al.* 2006).

Among the different spacing levels, wider spacing S_3 - 20 cm x 10 cm produced the maximum dry matter percent (12.43%) at harvest (Table 1) and the reason might be due to less interplant competition in wider spacing, resulting in higher fresh and dry weight of onion bulbs at harvest. This result was supported by previous findings of different authors (Islam *et al*. 1999, Hiray 2001, Sikder *et al*. 2008; Dhakulkar *et al.* 2009). It was found that spacing showed significant influence on dry matter percent of the onion bulbs.

In interaction of nitrogen and spacing, treatment combination N_3S_3 (100 kg N/ha and 20 cm × 10 cm spacing) recorded maximum dry matter percent (12.81%) at harvest, and the lowest dry matter percent (11.47%) was recorded at N_1S_1 (control-0 kg N/ha and 10 cm × 10 cm spacing). However, the interaction did not affect the dry matter content of onion bulbs.

Effect of nitrogen and spacing on harvest index of common onion

Analysis of the result in Table 1 showed that nitrogen had a significant influence on the harvest index of common onion and maximum harvest index of common onion was recorded at higher nitrogen dose N_4 - 150 kg N/ha (85.99%). This indicates that increasing nitrogen application increased bulb dry weight, total dry weight of whole plant and growing period, resulting in an excellent source-sink relationship that resulted in the maximum partition of assimilates from vegetative parts towards bulbs, thereby increasing the harvest index of common onion. Similar result was also reported in the findings of (Gebretsadik and Dechassa 2016).

It was found that wider spacing S_3 - 20 cm x 10 cm recorded the maximum harvest index (81.62%) of common onion (Table 1). The reason for maximum harvest index in wider spacing might be due to lesser competition among wider spaced plants which increased both bulb dry weight and total biomass yield, thus improving the harvest index of common onion. The result was in line with the findings of (Muthal *et al*. 2019). However, spacing had no significant effect on the harvest index of common onion.

For interaction of nitrogen and spacing, N_4S_3 (150 kg N/ha and 20 cm × 10 cm spacing) exhibited the maximum harvest index (86.31%) compared to other treatment combinations and minimum record was obtained at N_1S_1 (74.54%). However, there was no significant effect of the interaction of nitrogen and spacing on the harvest index of common onion.

Effect of nitrogen and spacing on economics of common onion cultivation

The cost-return relationship of a particular crop is a major factor in determining the farmer's crop cultivation. Any agronomic practice that is implemented should have a positive impact on the cost-return relationship. The farmer uses the technique, which lowers the cost of cultivation while increasing profit. Economics of common onion cultivation influenced by different nitrogen, spacing and their interaction is calculated in terms of total cost of cultivation (Rs/

Table 2. Effect of nitrogen and spacing on economics of common onion cultivation.

Treatment combinations	Total cost of cultivation (Rs/ha)	Yield (t/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	Benefit-cost ratio (B:C)
N_1S_1	381080	40.69	1424150	1043070	2.74
N_1S_2	368180	28.58	1000300	632120	1.72
N_1S_3	361730	22.77	796950	435220	1.20
N_2S_1	383254	44.12	1544200	1160946	3.03
N_2S_2	370354	31.56	1104600	734246	1.98
N_2S_3	363904	25.84	904400	540496	1.49
N_3S_1	385428	49.40	1729000	1343572	3.49
N_3S_2	372528	35.45	1240750	868222	2.33
N_3S_3	366078	28.92	1012200	646122	1.76
N_4S_1	387602	56.05	1961750	1574148	4.06
N_4S_2	374702	39.68	1388800	1014098	2.71
N_4S_3	368252	30.68	1073800	705548	1.92

Note: Market value of common onion = Rs 35/kg, Cost of urea = Rs 20/kg, Cost of seed = Rs 2580/kg, Rs = Rupees, N = Nitrogen; S = Spacing.

ha), gross returns (Rs/ha) and net returns (Rs/ha). The benefit to cost relationship was calculated to know the profitability of each treatment combination.

The cost of cultivation of common onion was calculated based on fixed cost and input cost incurred on cultivation. Among the treatment combinations, N_4S_1 (150 kg N/ha and 10 cm x 10 cm spacing) had incurred the highest total cost of cultivation of Rs 387602/ha (as shown in Table 2) due to maximum quantity of nitrogen fertilizer and maximum seed rate utilized in higher plant population, which increased the expenses to procure fertilizer and seeds.

Gross returns (Rs 1961750/ha) and net returns (Rs 1574148/ha) were maximum in the treatment combination N_4S_1 (150 kg N/ha and 10 cm x 10 cm spacing) due to higher yield per hectare. The result was in agreement with the findings of (Kadari *et al.* 2019). Similarly, the benefit to cost ratio (B:C) was maximum (4.06:1) in the treatment combination N_4S_1 (150 kg N/ha and 10 cm x 10 cm spacing). Higher yield and thus higher monetary returns might explain the maximum benefit to cost ratio (B:C) in the interaction of higher nitrogen dose and closer spacing (Table 2). The result was similar with the previous findings of (Hiray 2001, Kadari *et al.* 2019).

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