

## Performance Evaluation of Cabbage Cultivars under Open Field Cultivation in High Altitude of Tawang, Arunachal Pradesh

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### ABSTRACT

The study has been undertaken to evaluate the performance of locally available commercial cultivars of cabbage in open field during summer season of 2019 at Defence Research Laboratory Research and Development Centre Tawang (Arunachal Pradesh). The commercial cultivars of these vegetables were evaluated based on the growth parameters and their yield performance under open field with paired row system of planting. It was found that the cultivar Green Express performance was outstanding among test edcultivars and it superseded cv. Royal Ball BC-51 and cv. Blue Jayes in terms of growth parameters as well as marketable yield (2.62 kg/m<sup>2</sup>) and biological yield (3.47 kg/m<sup>2</sup>). The cv. Royal Ball BC-86 was also found next best performing cultivar after cv. Green Express as former was at par with growth and yield parameter and harvest maturity of later. The head of cv. Green express attended harvest maturity (149.25 days) approximately one week earlier as compared to cv. Blue Jayes (155.0 days). However, the productivity of cultivars Green Express and Royal Ball BC-86 was found within the range of national average, therefore, these two cultivars could be recommended for the commercial cultivation with paired row system of planting under open field cultivation during summer season in high altitude areas of Tawang (Arunachal Pradesh).

**Keywords:** Cabbage; Cultivars; Growth; Paired row planting and yield

### 1. INTRODUCTION

The cabbage (*Brassica oleracea* var. *capitata* L.) is used as leafy green vegetable and is a member of *Cole* group of vegetables hailing from mustard family *Brassicaceae*. It is a biennial, herbaceous, dicotyledonous flowering plant distributed mainly on the northern subtropical to temperate region of the world, and evolved from wild relatives growing on the European coasts of the Atlantic and the northern Mediterranean region<sup>1</sup>. India is second largest producer of cabbage after China<sup>2</sup>. It is one of the most abundant vegetable crops of high-altitude regions of Arunachal Pradesh especially Tawang<sup>3</sup> because of its adaptability and variety of culinary uses in local preparations. Nevertheless, cabbage is packed with natural fibres and a treasure of natural anticancer phytochemical compounds such as beta-carotene, tocopherols, phenolics, minerals, glucosinolates, and vitamins particularly vitamin A and vitamin C etc.<sup>4,5</sup> Recent studies suggested fermented cabbage as a proof-of-concept of dietary manipulations that may enhance nuclear factor (erythroid-derived 2)-like 2 (Nrf2)-associated antioxidant effects, helpful in mitigating COVID-19 severity as cabbage is a storehouse for precursors of sulforaphane, the most active natural activator of Nrf2<sup>6</sup>.

Tawang, with second largest Monastery of Asia, is the most important pilgrimage of followers of Buddhism and is located in high altitude areas of Indian state Arunachal Pradesh.

The district is strategically important for the nation owing to its geographical location and international border with Tibet to the north and Bhutan to the west. The climate of this region is predominantly temperate and warm which falls under category of *Cwb* according to Koppen 1918<sup>7</sup> and Geiger 1954<sup>8</sup>. The alpine and sub alpine zones of this region remain snowbound coupled with sub zero temperatures during winter months of the year which render it to unsuitable for agricultural activities in open fields. However, the summer season allows growing vegetable crops of mainly *Brassica* group such as cabbage, cauliflower, radish, leafy mustard etc. in open fields located in comparatively low-lying areas. The national average of cabbage productivity is 22.7 MT/ha<sup>9</sup>. There exists a huge gap in productivity of crops in general and cabbage in particular in these areas because of poor quality seed material, low seed replacement ratio and age-old farming practices followed by tribal communities in addition to climatic adversaries and soil conditions<sup>10</sup>. Moreover, the frequent incidences of landslide due to heavy rainfall during summer season in high altitude areas restrict the transportation of the goods from lower areas to cater the local vegetable requirement<sup>11</sup>.

Keeping above in view Defence Research Laboratory Research and Development Centre (DRL R&D Centre) at Tawang, the study was undertaken to evaluate the commercial cultivars of cabbage and hereinafter to screen out the highest yielding cultivar to raise the productivity of local landholdings under prevailing climatic conditions.

**Table 1. Physicochemical properties of soil of experimental site**

Parameter	Approximate value	Analytical method	Reference
Soil pH	4.61	Glass electrode digital pH meter	Jackson, (1973) <sup>18</sup>
Soil Electrical Conductivity (dS/m)	0.03	Conductivity meter	Jackson, (1973) <sup>18</sup>
Organic Carbon (%)	2.10	Modified Walkley and Black method	Black, (1965) <sup>19</sup>
Available Nitrogen (kg/ha)	260.1	Alkaline potassium permagnate method	Subbiah and Asija, (1956) <sup>20</sup>
Available Phosphorus (kg/ha)	25.5	Bray's No. 1 method	Bray and Kurtz, (1945) <sup>21</sup>
Available Potassium (kg/ha)	141.4	Flame emission spectrometry method	Jackson, (1973) <sup>18</sup>

## 2. MATERIAL AND METHODS

### 2.1 Experimental Site, Soil and Climate

The experiment was undertaken during summer season (March to October) of 2019 at Defence Research Laboratory Research and Development Centre (DRL R&D Centre) Tawang (Arunachal Pradesh). The experimental station is located around 27°45' North and 91°15' East at an altitude of 3015 meters above mean sea level in the high-altitude region of Eastern Himalayas. The climate of the experimental site is temperate (alpine and sub alpine) and warm and received an average rainfall of 895 mm during growing season. The site experienced an average minimum and maximum temperature of 8 °C and 19.6 °C, respectively during growing season. The soil of the location is silty clay loam and some of the soil physicochemical properties are given in Table 1.

### 2.2 Experimental Details

The commercially available cultivars of experimental crop (*Brassica oleracea* var. *capitata* L.) were selected so that farmers of high-altitude area, who generally procure the seed material either from local vendors of Tawang or from Tezpur city of Assam, could purchase the best cultivar in their vicinity keeping in view its availability and access after its recommendation. Hence, the soilless nursery of locally available cultivars namely 'Green Express', 'Royal Ball BC-51', 'Royal Ball BC-86' and 'Blue Jayes' collected from certified nursery of Tezpur, Assam was raised. The seedlings were raised in 98 celled pro trays under polycarbonate (6 mm thickness) clad naturally ventilated nursery house. The nursery was prepared 30 days advance of the transplanting in main field at the start of summer season (mid-March). The overnight presoaked seeds of each cultivar of cabbage were sown in 'V' type nursery prepared with growing media cocopeat:pearlite:vermiculite in 3:1:1 ratio. The seedlings of each cultivar attended two true leaf stage approximately in 4 weeks. The seedlings were transplanted on first fortnight of April 2019 during summer season in open field manured with vermicompost at the rate of 5 kg per square meter area and fertilised with recommended dose of fertilisers as blanket application. The raised beds of 2.6m x 1.8m were prepared 15 cm above the ground keeping in view the soil dismantling effect of the heavy rains during the growing season.

Paired row system of planting was followed in which two rows of each cabbage cultivar were spaced together at 30 cm followed by a wide spacing of 50 cm before the next set of two rows. The plants within the row were spaced 30 cm apart. The

cabbage heads were harvested during morning hours by hand by bending the stalk to one side and cutting it with a sharp knife.

### 2.3 Observations Recorded

#### 2.3.1 Number of Leaves

A competitive plant of each cultivar was selected randomly from each replication at the time of harvest and number of outer leaves per plant counted manually and average value is reported.

#### 2.3.2 Fresh Weight (g/plant)

The fresh weight of randomly selected competitive plant of each cultivar under study from each replication was measured with electronic balance (least count 100 mg) and the average of values recorded in quadruplets is expressed in grams.

#### 2.3.3 Harvest maturity (days)

The harvest maturity was judged by visual observation of colour break of the outer leaves started turning yellow. The cabbage was harvested when the heads were compact, but still firm and felt solid on tapping. The duration of harvest maturity was determined by counting the period from transplanting to date of harvesting including age of seedlings in nursery.

#### 2.3.4 Marketable and Biological Yield (g/m<sup>2</sup>)

The marketable yield and biological yield were calculated on the basis of fresh weight of roots, stalk, head and outer leaves at the time of harvest and expressed in gram per square meter using following formula:

Biological yield (g/m<sup>2</sup>) = Marketable yield (g/m<sup>2</sup>) + weight of outer leaves and stalk (g/m<sup>2</sup>) + root weight (g/m<sup>2</sup>).

### 2.4 Statistical Analysis

The experiment was laid out in randomised block design (RBD) and the data was recorded in quadruplets over the growing season in open field cultivation (OFC). The statistical analysis was carried out for each observed parameter through MS-Excel and OPSTAT software. Entire data was statistically analysed as per prescribed principles of design of experiment suggested by Gomez and Gomez (1984)<sup>12</sup>.

## 3. RESULTS

The fresh weight of head and number of leaves varied significantly across the cabbage cultivars. Highest fresh weight was recorded in cabbage cv. Green Express while highest number of outer leaves per plant observed in cv. Royal Ball

**Table 2. Performance of commercial cultivars of cabbage in open field cultivation at Tawang**

Cultivar	Fresh weight (g/head)	No. of leaves per plant	Harvest maturity (days)	Marketable Yield (kg/m <sup>2</sup> )	Biological Yield (kg/m <sup>2</sup> )
Green Express	391.22	10.50	149.25	2.62	3.47
Royal Ball BC-51	342.68	10.75	151.0	2.14	2.80
Royal Ball BC-86	380.15	11.25	153.5	2.48	3.33
Blue Jayes	347.34	9.25	155.0	2.18	2.85
S.Em±	3.68	0.29	1.24	0.08	0.15
CD <sub>0.05</sub>	11.95	0.95	4.03	0.27	0.48

BC-86. However, these cultivars were found statistically *at par* with respect to fresh weight of head as well as number of leaves per plant. Further, the head of cultivars Blue Jayes and Royal Ball BC-51 partitioned significantly less fresh weight and outer leaves per plant as compared to cultivars Green Express and Royal Ball BC 86 while there was no significant difference recorded between the two with respect to these growth parameters (Table 2).

The cultivar Green Express followed by Royal Ball BC-51 was early in attaining harvest maturity among the cultivars. The cultivars Green Express, Royal Ball BC-51 and Royal Ball BC-86 were found statistically *at par* to attain harvest maturity stage. However, the cv. Blue Jayes took significantly higher number of days to attain harvest maturity as compared to cv. Green Express (Table 2).

The maximum marketable yield was noted with the cv. Green Express that was statistically *at par* with cv. Royal Ball BC-86 and significantly higher than the cultivars Royal Ball BC-51 and Blue Jayes. However, there was no significant difference recorded between the marketable yield of Royal Ball BC-51 and cv. Blue Jayes. Similar findings were also reported from Tawang<sup>13</sup>.

The head and foliage comprised of outer leaves, short thick stem and roots in all the cabbage cultivars under study was found varying significantly. The cultivar Green Express recorded significantly higher amount of biological yield as compared to cv. Royal Ball BC-51 and Blue Jayes. However, the biological yield of cv. Royal Ball BC-86 was found statistically *at par* with Green Express and Blue Jayes (Table 2).

#### 4. DISCUSSION

The significant variation among cabbage cultivars with respect to fresh weight of head and number of outer leaves per plant might be due to the close spacing followed in paired row system of planting. There are evidences of prominent effects of plant spacing on the structure of cabbage<sup>14</sup>. Similarly, the harvest maturity and marketable yield variation among the cultivars might be due to the plant spacing, which was kept closure resulted in accommodation of a greater number of plants per unit area. Keeping low plant population in cabbage has increased cabbage head size with simultaneous reduction in marketable yield per hectare was also observed

by Cizinszky and Schuster (1985)<sup>15</sup>. Although, the cv. Royal Ball BC-51 and cv. Blue Jayes did not attain the equal level of production as compared to best performing cultivar Green Express, the paired row system of planting maybe overestimated for these cultivars. These cultivars may perform better in terms of growth and yield under different land configuration and environmental conditions such as raised bed planting or ridge system under low tunnels or low-cost polyhouses or even in naturally ventilated greenhouses, which is a matter of further investigation. The higher number of days taken by these cultivars to attain harvestable maturity probably because of longer duration in stand establishment due to slow initial growth and late onset of heading stage as observed in the open field conditions.

A fair amount of left-over material out of biological yield of cabbage cultivars Green express and Royal Ball BC-86 was recorded, which might be due to significantly higher number of outer leaves and stalk thickness. It is reported that there is shortage of forage material for animals in high altitude areas even in rainy season because of majority of the farmers are dependent on natural resources owing to lack of irrigation facilities, topography of the region, small size land holdings etc.<sup>16</sup>Hence, the selection of these cultivars instead of local cultivars would not only provide optimised marketable yield for human consumption but also the nutritious fodder for the livestock. Moreover, the outer leaves of cabbage are a rich source of biomolecules such as proteins, soluble sugars in addition to macro and micro elements and have good digestibility with fair amount of dietary fibre and dry matter intake that can be effectively utilised as nutritious fodder for ruminants<sup>17</sup>.

#### 5. CONCLUSIONS

The growth and yield performance based preliminary screening of commercially available cultivars of cabbage shows potential for improvement in its productivity at high-altitude areas of Arunachal Pradesh. The early maturity in cultivars is a desirable character in hilly areas to escape from vagaries of weather within the short period of growing season permitted by the prevailing climatic conditions. Since, the cv. Green Express and cv. Royal Ball BC-86 registered a significant percentage increase in yield (by 5 to 20 % approximately) and found early by around 1 week in harvestable maturity as compared to rest, hence, are suitable for cultivation in open field conditions under paired row system of planting during summer season at high-altitude of Tawang and the regions of Arunachal Pradesh with similar climatic conditions. However, there is further scope for the optimisation of yield of cabbage through adoption of plastic mulching, low-cost tunnels and integrated nutrient and pest management practices etc. under prevalent climate of high-altitude at Tawang.

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