

Original Research Article

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Effect of Growth, Physiological Aspects and Yield of Cabbage (*Brassica oleracea* L. cv Rareball) in Knolkhol and Broad Bean Intercropping System under Imphal West Condition

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ABSTRACT

An investigation was carried out to study the effect of intercropping crops (knol khol and broad bean) on growth, physiological aspects and yield of Cabbage. Sole crop of Cabbage was grown and between the inter-row spaces knol khol/broad bean was intercropped in single/double row planting. Spacing of 60 x 30 cm between cabbage and 30 x 30 cm for knol khol and 30 x 20 cm for broad bean was adopted. Growth parameters were recorded for cabbage as sole crop and as intercropped with single/double row of knol khol / broad bean. Maximum fresh weight (376.80 g) and dry weight (45.10 g) of the plant were observed in cabbage as sole cropping at 75 DAT which is at par with cabbage intercropped with single row of broad bean with fresh weight (344.13 g) and dry weight (41.56 g). However, on complete analysis of the physiological parameters, it can be concluded that cabbage sole cropping, recorded highest harvest index (64%), net assimilation rate (0.0344 g m⁻²day⁻¹), plant growth efficiency (30.30%), crop growth rate (2.08 g cm⁻² day⁻¹), relative growth rate (0.0306 g g⁻¹day⁻¹) except leaf area index in which cabbage intercropped with single row of broad bean (1.16), exhibited maximum. Superiority in physiological parameters like leaf area index (1.16) and harvest index (64.00 %) was recorded in Cabbage with single row broad bean and sole crop of cabbage, respectively. The maximum weight of the head (875.54 g), the maximum compactness (30.30) and maximum yield was found 48.2 t/ha in cabbage sole cropping (T₁) which remained at par with cabbage intercropped with single row (776.51 g) of broad bean (T₄), (29.78) and 44.71 t/ha. Remarkable variation was observed in the performance of cabbage intercropped knol khol and broad bean under Imphal west condition.

Keywords

Cabbage, Growth, Intercropping, Harvest Index, PGE, NAR, CGR, RGR, LAI

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Introduction

Cabbage (*Brassica oleracea* L.) belongs to the cruciferae family and is originated in Mediterreanean region. In India, the major

cabbage producing states are Uttar Pradesh, Bihar, Odisha, West Bengal, Assam, Maharashtra and Karnataka. In spite of wide scope and importance only limited efforts have been made towards cabbage research and

development in Northeast region of India. There is need for focused research efforts to increase the area and production of crops like cabbage along with some minor crops to meet the nutritional requirements and also for the economic upliftment of people of these areas. Intercropping is a very important cropping system from farmer's economic point of view if the intercrops are selected properly. This cropping system will enhance the economic condition of farmers by increasing the crop intensity. Cabbage is cool season crop which require wider spacing. Crops like knol khol and broad bean which are having upright habit and require less spacing (Swarup, 2006) can be grown in between the cabbage plant as intercrops. Moreover, knol khol is short duration crop which is ready for harvesting by the time head formation starts in cabbage which gives lesser competition during the head formation of cabbage. Broad bean has straight and non-branching morphology which does not hinder the canopy of cabbage when broad bean is grown as intercrop and also broad bean has biological nitrogen fixation ability (Swarup, 2006) which gives additional nitrogen availability to the soil. Furthermore, broad bean is luxurious crop which fetch higher market price and ultimately gives higher return as compared to sole cropping of cabbage. No cultivable land under cabbage has been noticed in Manipur. Manipur is not having any local cabbage lines. So, Rareball variety of cabbage is used to study in the intercropping system with local lines of broad bean and Winner variety of knol khol to compensate in case of crop failure and ensure the profitable returns along with the food security for small holdings of Manipur. Even though inclusion of any of the intercrops reduced the yield of main crop (Chattopadhyay *et al.*, 2008, Singh *et al.*, 2013), highest profitability was recorded among intercropped treatments (Quayyam and Ebrahim 1988). Salter (1986) indicated that simultaneous growing of two or more crops

not only gives more yield and net profit but it also cuts the cost of cultivation. In N E Region not much research works on the growing practice of intercrops in vegetable garden like cabbage, cauliflower, etc. has been conducted and literature is also limited. Therefore, the present investigation was carried out to study the growth, physiological aspects and yield of cabbage cv. Rareball intercropped with knol khol and broad bean under Imphal West condition.

Materials and Methods

The present investigation was carried out in College of agriculture, Central Agricultural University, Imphal, Manipur. It is located at North-Eastern Hill Region of India with 94°E longitude; 24°N latitude and an altitude of 875.0 meter above mean sea level during the year 2016-17 with cabbage cv. Rareball, knolkhol cv. winner and broad bean local variety. The experimental soil was acidic (pH 5.40) and clay soil. The experiment was laid out in a Randomized Block Design with seven treatments and three replications. The treatments comprised of cabbage sole crop (T₁), single row of knol khol planted in the inter-rows cabbage (T₂), double row of knol khol planted in the inter-rows cabbage (T₃), single row of broad bean planted in the inter-rows cabbage (T₄), double row of broad bean planted in the inter-rows cabbage (T₅), knol khol sole crop (T₆) and broad bean sole crop (T₇). Spacing of 60 x 30 cm row to row and plant to plant was adopted for cabbage constantly. Knol khol planted at a distance of 30 x 30 cm row to row and plant to plant in sole cropping, Broad bean sown at a distance of 30 x 20 cm row to row and plant to plant in sole cropping. Where as in single row planting, only one row of broad bean/knol khol planted in the inter-rows of cabbage and in double row planting, 2 rows of knol khol/broad bean planted in the inter-rows of cabbage. The number of knol khol plants

present in single row (56), double row (112) and the sole crop (64) will vary accordingly and number of broad bean plants present in single row (84), double row (168) and the sole crop (96) will vary accordingly. One month old seedlings of cabbage and knol khol were transplanted whereas soaked broad bean seed are directly sown in plot size of 2.4m x 2.4m. Recommended cultural practices and plant protection measures were carried out regularly. The harvested heads, knob and pods of cabbage, knol khol and broad beans respectively from each plot were weighed separately and yield per plot was obtained then converted into tonnes per hectare. Five uniform plants were selected randomly in each treatment for recording plant height (cm) from base to the tip of the plant, number of open leaves per plant, canopy of the plant (cm²) and leaf area (cm²) at 15 days interval from 30DAT to 75 DAT. Two plants from each plot were taken as destructive sample for recording total fresh weight of plant (g), weight of the head (g), size of the head (cm²), total dry weight of plant (g) at 45, 60 and 75 DAT.

Leaf area index (LAI) of the plant and harvest index (%) were recorded by the formula given by Watson (1947) and Yoshida (1981), respectively.

$$\text{Leaf Area Index} = \frac{\text{Total leaf area (cm)}}{\text{Canopy of the plant (cm}^2\text{)}}$$

$$\text{Harvest Index} = \frac{\text{Economical yield}}{\text{Biological yield}} \times 100$$

Net assimilation rate (NAR) (g/m²/day), plant growth efficiency (PGE) (%), crop growth rate (CGR) (g/day) and relative growth rate (RGR) (g/g/d) were recorded by the following formulae given by Gregory (1926), Gardner *et al.*, (2010) and Reddy and Reddi (2008), respectively:

$$\text{NAR} = \frac{W_2 - W_1}{L_2 - L_1} \times \frac{\log L_2 - \log L_1}{t_2 - t_1}$$

Where, W₁ and W₂ refer to the whole plant dry weight and L₁ and L₂ refer to Leaf area on two successive periods at t₁ and t₂.

$$\text{PGE} = (D_2 - D_1) / D_m \times 100$$

Where, D_m= maximum dry weight at harvest, D₁= dry weight of plant at time 1, D₂= dry weight of plant at time 2

$$\text{CGR} = \frac{W_2 - W_1}{t_2 - t_1}$$

Where, W₁ and W₂ refer to the whole plant dry weight per m² land area on two successive periods at t₁ and t₂ respectively.

$$\text{RGR} = \frac{\log w_2 - \log w_1}{t_2 - t_1}$$

Where, W₁ and W₂ refer to the whole plant dry weight on two successive periods at t₁ and t₂.

Head compactness of cabbage is measured at harvest (90 DAT) on the basis of Z-value as per the method of Pearson (1931). Z-values were calculated by the formula:

$$\text{Compactness (Z)} = (C \times 100) / W^3$$

Where,

Z = index of compactness

C = net weight of the head

W= average of the lateral and polar diameter of the head

Results and Discussion

Growth parameters of cabbage

Knol khol and broad bean raised as intercrop affected the growth of cabbage (Table 1) significantly under all the treatments. At 75 DAT maximum plant height (29.13 cm),

number of open leaves (21.87), canopy area (646.07 cm²), leaf area (28.93 cm²), fresh weight (376.80 g) and dry weight (45.10 g) were recorded from sole crop of cabbage which were at par with the treatment in which cabbage intercropped with single row of broad bean except canopy area and which are significantly higher than the rest of the treatments. Among the observations recorded from the destructive samples, maximum fresh weight (376.80 g) and dry weight (45.10 g)

were recorded from sole crop of cabbage which remained at par with cabbage intercropped with single row of broad bean (T₄) which recorded maximum fresh weight of the plant (344.13 g) at 75 DAT among the intercropped treatments. Amanullah *et al.*, (2006a) and Silwana and Lucas (2002) also reported that intercropping reduced vegetative growth of component crops inline with the present findings.

Table.1 Effect of intercropping knolkhol and broad bean on growth parameters of cabbage at 75 DAT

Treatments	Plant height (cm)	Number of open leaves	canopy area (cm ²)	leaf area (cm ²)	fresh weight (g)	dry weight (g)
T ₁	29.13	21.87	646.07	28.93	376.80	45.10
T ₂	25.93	18.20	529.27	25.25	324.36	34.63
T ₃	25.40	16.87	487.00	24.80	285.20	29.85
T ₄	28.20	20.93	567.27	27.46	344.13	41.56
T ₅	26.50	19.73	549.53	26.21	338.67	39.03
T ₆	-	-	-	-	-	-
T ₇	-	-	-	-	-	-
S.Em (±)	0.48	0.73	10.37	0.73	10.83	1.50
CD (0.05)	1.58	2.39	33.88	2.39	35.39	4.90

Table.2 Effect of intercropping on yield and yield attributes of the cabbage

Treatments	weight of the head (single) (g)	size of the head (cm ²)	Compactness (Z)	Yield(t/ha)	
				Intercrops	Cabbage
T ₁	875.54	198.53	30.30		
T ₂	583.63	162.63	27.72	0.048.15	
T ₃	558.35	160.63	26.16	11.59	36.10
T ₄	776.51	194.49	29.78	21.35	34.71
T ₅	680.70	179.21	28.38	2.98	44.71
T ₆	-	-	-	4.39	41.11
T ₇	-	-	-	36.42	-
				7.55	-
SEm (±)	36.24	6.62	0.76	0.76	
C.D.(0.05)	118.41	21.63	2.50	2.48	

Table.3 Effect of intercropping knol khol and broad bean on physiological parameters of cabbage

Treatments	Leaf Area Index			Harvest Index	Net Assimilation Rate (g/m ² /day)		Crop growth rate (g/day)		Plant Growth Efficiency (PGE) (%)		Relative growth rate (g/g/day)	
	45 DAT	60 DAT	75 DAT	90 DAT	45-60 DAT	60 - 75DAT	45-60 DAT	60-75 DAT	45-60 DAT	60-75 DAT	45-60 DAT	60-75DAT
T ₁	0.84	1.13	1.11	64.0	0.0140	0.0344	1.08	2.08	9.86	30.33	0.0230	0.0306
T ₂	0.83	1.01	1.01	60.2	0.0122	0.0299	0.93	1.46	8.65	29.38	0.0203	0.0288
T ₃	0.71	1.07	1.01	58.6	0.0131	0.0253	0.87	1.22	8.60	27.53	0.0244	0.0278
T ₄	0.75	1.13	1.16	62.2	0.0156	0.0341	1.07	1.81	9.41	29.7	0.0260	0.0306
T ₅	0.74	1.01	1.07	61.1	0.0139	0.0330	1.03	1.71	8.74	29.42	0.0229	0.0310
T ₆	-	-	-	-	-	-	-	-	-	-	-	-
T ₇	-	-	-	-	-	-	-	-	-	-	-	-
SEm (±)	0.04	0.07	0.03	1.51	0.0022	0.0029	0.06	0.14	1.48	2.11	0.0033	0.0027
CD (0.05)	0.12	0.22	NS	4.93	0.0072	NS	0.19	0.46	NS	NS	Ns	Ns

Physiological parameters of cabbage

The data regarding the physiological parameters as affected by various treatments have been presented in Table 3. However, on complete analysis of the physiological parameters, it can be concluded that cabbage sole cropping, recorded highest harvest index (64%), net assimilation rate ($0.0344 \text{ g m}^{-2}\text{day}^{-1}$), plant growth efficiency (30.30%), crop growth rate ($2.08 \text{ g cm}^{-2} \text{ day}^{-1}$), relative growth rate ($0.0306 \text{ g g}^{-1}\text{day}^{-1}$) except leaf area index in which cabbage intercropped with single row of broad bean (1.16), exhibited maximum. In case of harvest index, cabbage sole cropping was found at par with other treatments except cabbage intercropped with double row of knol khol. This may be because the at 60 DAT the plant knol khol gets fully matured and at that time only the heading in cabbage starts which prevents the availability of proper sunlight. However, in case crop growth rate, cabbage sole cropping was found at par with cabbage intercropped with single row of broad bean and cabbage intercropped with double row of broad bean. Moreover, irrespective of all physiological parameters the treatments, cabbage sole cropping and cabbage intercropped with single row of broad bean remained at par. While net assimilation rate, plant growth efficiency, relative growth rate and leaf area index were remained non-significant with each other.

Yield of cabbage and intercrops

It has been noticed that the head formation of cabbage was initiated at 60 DAT. At harvesting stage there was significant difference among the treatments for weight of the head (g). The maximum weight of the head (875.54 g) was recorded in cabbage sole cropping (T_1) which was at par with cabbage intercropped with single row (776.51 g) of broad bean (T_4) and which was significantly

higher than the other treatments. Likewise, the maximum size of the head (198.53 cm^2) was recorded in cabbage sole cropping (T_1) which was significantly higher than cabbage intercropped with single row of knol khol (T_2) and cabbage intercropped with double row of knol khol (T_3) of 162.63 g and 558.35 g respectively (Table 2). However, the maximum compactness (30.30) found in cabbage sole cropping (T_1). The compactness in cabbage sole cropping (T_1) were found at par with cabbage intercropped with single row of broad bean (T_4) and double row of broad bean (T_5) and remained significant over cabbage intercropped with single row of knol khol (T_2) and cabbage intercropped with double row of knol khol (T_3). Moreover, for cabbage, maximum yield was found 48.2 t/ha in cabbage sole cropping (T_1) which remained at par with cabbage intercropped with single row (44.71 t/ha) of broad bean (T_4) and significantly performed superior over rest of the treatments. For knol khol and broad bean the maximum yield was found in sole cropping in both cases were 36.42 t/ha and 7.55 t/ha respectively while among intercropping more yield was obtained from double row of knol khol and broad bean as compared to single row respectively.

The experimental data showed that the competition between the cabbage and intercrops for various resources might pave the way for reduction in the above parameters.

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