

Research Article

Growth and yield parameters of F1 hybrids of tropical cabbage (*Brassica oleracea* var *capitata* L.) under open and protected conditions

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ABSTRACT

The present study was undertaken in the Department of Olericulture, College of Horticulture, Thrissur, Kerala. The objectives of the study were to identify an ideal hybrid of tropical cabbage for the plains and to study the feasibility of cabbage cultivation in on and off- seasons. The experiment was laid out in a Randomized Block Design with four replications. Four F1 hybrids namely NS183, NS43, NS35 (Namdhari Seeds Pvt Ltd.) and Disha (Semini India Pvt Ltd) were used for the study during off season (July-Oct) and on season (Oct-Jan). Protected conditions were provided using a rain shelter of 100m² floor area. The results revealed that NS43 was the earliest to achieve 50% head formation (during both seasons and growing conditions) and to achieve 50% maturity (during both seasons inside polyhouse). Net head weight was maximum for NS43 inside polyhouse during off-season and for NS35 inside and outside polyhouse during on-season. pest and disease incidence was more in open field during both seasons. NS43 and NS35 can be recommended for offseason and on season cultivation respectively. Rain shelter cultivation provides a conducive condition for the cultivation of an additional crop thereby providing extra income for the farmers.

INTRODUCTION

The popular Brassicaceae vegetable known as cabbage (*Brassica oleracea* var. *capitata* L.) is grown extensively worldwide due to its high economic and nutritional value [1]. In general, cole crops are susceptible to weather changes. The productivity and quality of a crop attains its maximum potential when grown in an environment that is optimum for that plant species. Suitable and meaningful manipulation of the environment is very important for sustainable agricultural production. In controlled environment conditions we can ensure optimum climatic conditions to achieve maximum productivity.

Rain shelter is a naturally ventilated low-cost polyhouse with only roof cladding and open sides. Its framework can be made permanent with G.I pipes or temporary with termite proof arecanut or bamboo poles. Cladding is provided with UV stabilized polythene film of 200-micron thickness. There is much scope for the cultivation of cool season vegetables inside these rain shelters during off seasons.

Hence this study was attempted to identify an ideal hybrid of tropical cabbage for plains based on the growth and yield parameters and to study the feasibility of cabbage cultivation in protected and open field conditions during on and off seasons.

MATERIALS AND METHODS

The present investigation was conducted in the Department of Olericulture, College of Horticulture, during 2010-2011 with the objective to study the performance of F1 hybrids of cabbage (*Brassica oleracea* var *capitata* L.) under protected and open conditions.

The site is located 10031' N latitude and 76013'E longitude and at an altitude of 22.25m above sea level. The area enjoys a typical warm humid tropical climate and receives an average rainfall of 3400mm per year. The soil of the experimental site comes under the textural class of

sandy clay loam and is acidic in reaction. The materials used and methods followed are presented below.

Protected structure

A low-cost rain shelter constructed in the Department of Olericulture was used for study and the design used was Randomized block design (RBD). The frame of the rain shelter is made up of G.I. pipes. Cladding is provided with UV stabilized low density polyethylene film (UVDPE) having a thickness of 200micron. The floor area was 100m² (20m X 5m) with a side height of 2m and central height of 3.5m

Open field

Plain land adjacent to rain shelter was utilized for evaluation of open field crop.

Varieties

Four F1 hybrids of cabbage were used for the study. They were evaluated during both the seasons in rain shelter and open field simultaneously in a randomized block design with four replications. Details of F1 hybrids used are given in Table 1.

Table 1. Name and source of hybrids used for the study.

Sl no.	Name of hybrids	Source
1	NS 183	Namdhari seeds Pvt Ltd
2	NS 43	Namdhari seeds Pvt Ltd
3	NS 35	Namdhari seeds Pvt Ltd
4	Disha	Semini India Ltd

Seasons

The research was carried out in two seasons viz. July – Oct 2010 (off-season) and Oct 2010- Jan 2011 (on -season) under two conditions (rain shelter and open field).



Nursery practices

Seeds were sown in plug trays filled with rooting medium of vermicompost and sand in the ratio 1:1 and one month old seedlings were transplanted to the prepared main field.

Preparation of main field

The experimental field was (open field and rain shelter) cleared and ridges were taken in each plot (3m²) and a basal dose of farmyard manure at the rate of 25t/ha was applied before transplanting. Seedlings were transplanted at a spacing of 45 X 45 cm [2]. The field was laid out in RBD with four replications. There were ten plants per replication. Gap filling was done ten days after transplanting.

Fertilizer application

Urea, superphosphate and potash were the source materials for supplying nutrients N, P₂O₅ and K₂O respectively. These nutrients were mixed based on the package of practices recommendation 150:100:125 kg/ha. Full dose P₂O₅ and half dose of N and K₂O were applied before transplanting and half dose was applied one month after transplanting [2].

After cultivation

Regular weeding and earthing up were done inside the rain shelter and in open field. Diseased and damaged plants were removed regularly.

Plant protection

Seedlings were drenched with *Pseudomonas fluorescens* (20 g/L) to prevent nursery diseases. *Alternaria* leaf spot was controlled by spraying Mancozeb 2 g/L in the main field. Ekalux 2 ml/L was sprayed in nursery to prevent caterpillar attack. Fipronil 2 g/l was sprayed in the main field to control *Spodoptera litura*.

Harvesting

Heads were harvested at marketable stage.

Observations

Five plants per replication of each treatment were selected for recording observations. Qualitative and quantitative observations were recorded as per the description of NBPGR [3] like early plant vigor, leaf color, number of wrapping and non-wrapping leaves, plant spread and stalk length. Characteristics of the cabbage head like compactness, shape, length, breadth, core length and head index were also recorded. Pest and disease incidences and meteorological observations were recorded daily during the cropping period.

Statistical analysis

The data recorded on vegetative and yield characters were statistically analyzed by using statistical package (MSTAT-C) [4]. Simple correlation between plant characters like days to 50% head formation, 50% head maturity and yield per harvest with weather parameters like maximum and minimum temperature, relative humidity and rainfall were computed.

RESULTS

Days to 50% head formation

During off season, minimum number of days to 50% head formation was observed in the hybrid NS43 and it achieved 50% head formation in 52.00 days followed by NS35 (59.26), NS183 (59.00) and Disha (58.8). In open field, 50% head formation was not observed till the end of the season in any of the hybrids (Table 2).

Table 2. Days to 50% head formation and 50% head maturity as influenced by varieties during off season inside rain shelter

Treatment	Days to 50% head formation	Days to 50% head maturity
T1(NS183)	59.00	88.25
T2(NS43)	52.00	74.5
T3(NS35)	59.25	85.00
T4(Disha)	58.80	90.50
CD(p<0.05)	6.584	5.372

During main season, inside the rain shelter minimum number of days for 50% head formation was observed in the hybrid NS43 (50.00) and was on par with NS183 and Disha (52.75). In the hybrid NS35 50% head formation was observed in 57.25 days inside the rain shelter. In open field head formation was earlier when compared to the rain shelter during main season. NS43 was earliest (49.25) followed by Disha (50.25) and it was on par with NS183 and NS35 (52.00). From Table 3, it is clear that NS 43 was the earliest. Mean number of days for 50% head formation under open field condition was 50.87 and inside it was 53.00 (Fig. 1).

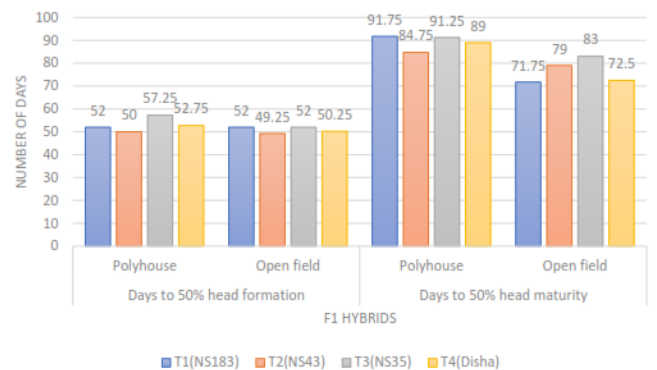


Fig. 1. Days to 50% head formation and maturity as influenced by growing condition during main season.

Days to 50% head maturity

During off season, under protected condition minimum number of days to 50% head maturity was observed in the hybrid NS43 (74.5). Hybrid NS35 took 85 days to obtain 50% head maturity and it was on par with Disha (90.50) and NS183 (88.25) (Table 3; Fig. 2).

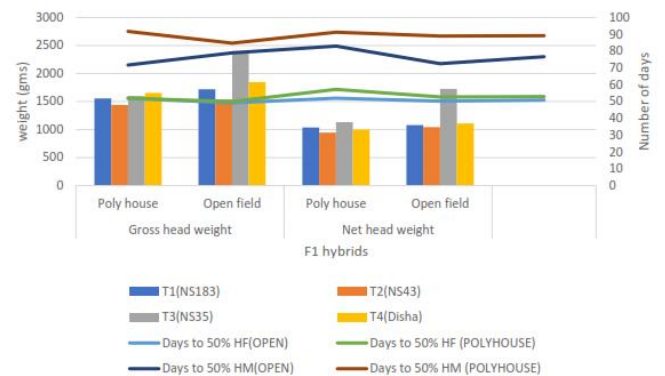


Fig. 2. Comparison of yield data and number of days to attain 50% head formation and maturity during main season.

Table 3. Days to 50% head formation and head maturity as influenced by growing condition during main season.

Treatment	Days to 50% head formation		Days to 50% head maturity	
	Polyhouse	Open field	Polyhouse	Open field
T1(NS183)	52.00	52.00	91.75	71.75
T2(NS43)	50.00	49.25	84.75	79.00
T3(NS35)	57.25	52.00	91.25	83.00
T4(Disha)	52.75	50.25	89.00	72.50
Mean	53.00	50.87	89.19	76.69
CD	3.023		8.545	

During main season also NS43 was found to be earliest (84.75) to mature inside the rain shelter and it was on par with other hybrids. NS183 and NS35 took 91.75 days and 91.25 days achieve 50% head maturity and Disha took only 89.00 days. In open field, NS183 was found to be early (71.75) when compared to other varieties and it was on par with NS43 (79.50). From the mean number of days to obtain 50% head maturity it was evident that the open field crop was earlier than the rain shelter crop during main season. The mean number of days inside the rain shelter was 84.18 and in open field it was 76.88 (Table 4).

Gross head weight

It was observed that during off season inside the rain shelter maximum gross weight was obtained for the hybrid NS183 (986.75g) and it was on par with NS43 (956.50g). NS35 recorded a gross head weight of 803.75g and Disha recorded 815.52g (Table 4; Fig. 3).

During main season, inside the rain shelter maximum gross weight was observed for the hybrid Disha (1655g) and it was on par with NS43 (1597.50g). Under open condition, the hybrids showed significant for this character with respect to the growing conditions and also among the hybrids. Maximum gross weight was observed for the variety NS35 (2401.00g) followed by the hybrid Disha (1847.50g) and NS183 (1720.50g). NS43 recorded a gross weight of 1536.00g. It was observed that the mean gross weight for the open field was higher than the protected crop during main season. while comparing the gross head weight with the days to attain 50% head formation and maturity it was found that NS35 was the highest yielder and also the late to mature (Table 5).

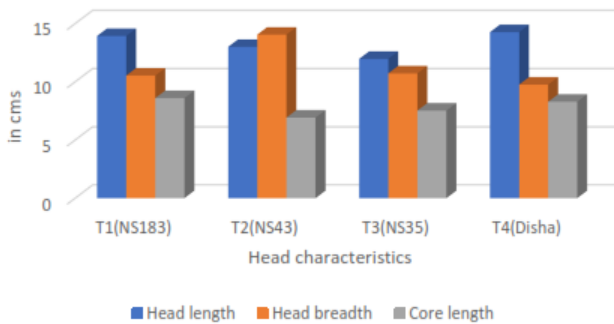


Fig. 3. Head characteristics during off season under protected conditions.

Net head weight

During off season, maximum head weight was observed in the hybrid NS183 (553.50g) which was on par with NS43 (545.75g). For the hybrid Disha (T4) it was found to be 431.0g. NS35 recorded a net head weight of 434.25g (Table 4).

The net head weight of hybrids during main season showed that in open field the value is higher when compared to the rain shelter crop. The mean net head weight in open field was 1239.37g and inside the rain shelter it was only 1027.87g. Maximum net head weight was observed for the hybrid NS35 in both open field condition and inside the rain

shelter. Under open field condition it recorded a net head weight of 1725.00g and inside the rain shelter 1131.0g. In the open field Disha recorded a net head weight of 1110.62g and NS183 recorded 1079.37g. NS43 recorded a net head weight of 1042.50g. Inside the rain shelter NS35 was on par with other hybrids. NS183 recorded a net head weight of 1037.50g. NS43 and Disha were found to have a net head weight of 945.50g and 997.50g respectively (Table 5).

Table 4. Gross head weight and net head weight (gms) as influenced by varieties inside rain shelter during off season.

Treatment	Gross head weight	Net head weight
T1(NS183)	986.75	545.75
T2(NS43)	956.50	535.50
T3(NS35)	803.75	434.25
T4(Disha)	815.25	431.00
CD(p<0.05)	169.457	125.367

Head length

During off season, inside the rain shelter maximum head length was observed for the hybrid Disha (14.26cm) and it was on par with NS183 (13.93cm). NS35 recorded a head length of 11.97cm and NS43 recorded a length of 13.00cm (Table 6).

During main season also, Disha recorded maximum head length inside the rain shelter (16.25cm) and it was on par with NS183 (15.91cm) and NS35 (15.54cm). Under open conditions, NS35 recorded maximum head length of 16.91cm and it was on par with Disha (15.29cm). NS43 was found to have a head length of 13.49cm and NS183 recorded 14.83cm. The mean head length inside the rain shelter was 15.59cm and that of outside crop was 15.13cm respectively (Table 7; Fig. 4).

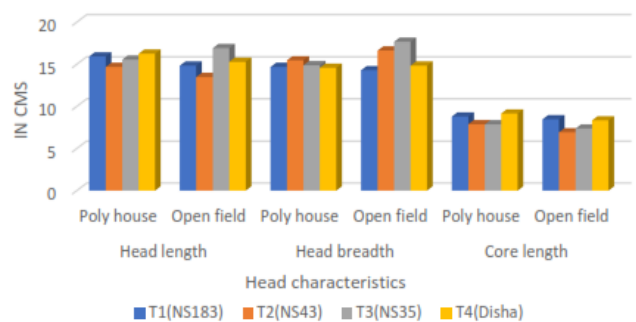


Fig. 4. Head characteristics as influenced by growing condition in main season.

Head breadth

During off season, inside rain shelter maximum value for head breadth was recorded for the hybrid NS43 (14.05cm). NS35 and NS183 were having 10.53cm and 10.72cm of head breadths respectively. Disha recorded a head breadth of 9.75cm. Maximum head breadth during main season crop was observed for the hybrid NS35 under open condition (17.66cm) and inside the rain shelter it was highest for NS43 (15.45cm). Inside rain shelter it was on par with other hybrids. NS183 recorded 14.87cm, NS 35 recorded 14.87cm and Disha achieved 14.58cm.

Table 5. Gross head weight (gms) and net head weight (gms) as influenced by growing conditions during main season.

Treatment	Gross head weight		Net head weight	
	Poly house	Open field	Poly house	Open field
T1(NS183)	1556.00	1720.50	1037.50	1079.37
T2(NS43)	1438.50	1536.00	945.50	1042.50
T3(NS35)	1597.50	2401.00	1131.00	1725.00
T4(Disha)	1655.00	1847.50	997.50	1110.62
Mean	1561.75	1876.25	1027.87	1239.37
CD	330.244		264.300	

Core length

During off season, inside the rain shelter minimum core length was observed for NS43 (6.92cm) and it was on par with NS35 (9.52cm) and Disha (8.28cm). NS183 recorded 8.60cm inside rain shelter.

Core length inside the rain shelter during main season was minimum for NS43(7.87cm) and it was on par with NS183 (8.79cm) and NS35 (7.87cm). Disha recorded a core length of 9.16cm inside the rain shelter during main season. Under open conditions NS43 also was having minimum core length of 6.91cm and it was on par with NS35 (7.35cm). Disha had a core length of 8.33cm and NS183 (8.46cm). Mean core length of outside crop was found to be lower than that of rain shelter crop. Mean core length inside the rain shelter was 8.42cm and that under open condition was 7.77cm.

Head index

During the off season, NS183 recorded a head index of 1.34. NS43 had a head index value of 0.92 and NS35 with 1.12. Disha showed a head index of 1.48 inside the rain shelter.

During the main season, inside the rain shelter NS183 recorded a head index of 1.09 and 1.03 under open filed condition. For NS43, it was 0.95 inside rain shelter and 0.82 under open field. NS35 shows a value of 1.02 inside rain shelter and 0.95 under rain shelter and for Disha the value was 1.11 inside rain shelter and 1.03 under open field condition.

Harvest index

During the off season, inside the rain shelter harvest index was found to be maximum for NS43 (67.70) which were on par with NS183 (60.46). NS35 recorded a harvest index of 55.65 and Disha was found to have a harvest index of 55.01 (Table 8).

During the main season, maximum harvest index was observed for NS35 under rain shelter and open field. Harvest index for NS35 was 72.00 in open field and 70.75 inside rain shelter. Inside the rain shelter NS35 was on par with NS183. NS183 recorded a harvest index value of 66.50 inside the rain shelter and 63.25 in open field. In open condition NS35 was on par with NS43 (67.50). NS43 recorded 65.00 inside the rain shelter. Disha was found to have a harvest index value of 60.00 both inside rain shelter and in open field (Table 9).

Table 6. Head length, Head breadth and Core length as influenced by varieties inside rain shelter during off season.

Treatment	Head length	Head breadth	Core length
T1(NS183)	13.93	10.53	8.60
T2(NS43)	13.00	14.05	6.92
T3(NS35)	11.97	10.72	7.52
T4(Disha)	14.26	9.75	8.28
CD(p<0.05)	0.888	1.557	1.365

Total number of marketable heads

The hybrids did not differ significantly for the character observed during off season and main season under both growing conditions i.e., inside rain shelter and under open field conditions and found to be non-significant.

During the off season, out of the ten plants NS43 obtained maximum number of marketable heads (8.75) followed by NS35 (8.00), NS183 (7.00) and Disha (6.75). During on season also, NS43 obtained maximum number of marketable heads (7.75) followed by NS183 and Disha (7.50) and NS35 (7.25) inside the rain shelter. Under open field, NS35 and Disha formed maximum number of marketable heads (7.75) followed by NS183 (7.25) and NS43 (6.00).

Pest incidence

During the off season, pest incidence was more in open field. *Spodoptera litura* was the major pest found during the off season. Among the treatments lowest pest incidence was noticed in the hybrid NS35 (2.5%) inside the rain shelter followed by Disha (7.5%), NS183 (15%) and NS43 (20%). Under open field conditions minimum incidence was observed in Disha (9.47%), followed by NS35 (16.67%), NS183 (19.46%) and NS43 (24.95%). Inside the rain shelter it was controllable but under open conditions it was uncontrollable because of the rainfall during the off season.

During the main season, incidence was more under open field conditions. but under both growing conditions incidence was higher than that during the off season. During the main season also, *Spodoptera litura* was the major pest attacking the crop. But in the early stages of the crop spotted bug incidence was also noticed. Cabbage cluster caterpillar (*Crociodolomia binotalis*) attack was also observed. Inside the rain shelter pest attack was found to be lowest for NS43 and NS35 (17.5%) and maximum for NS183 (25%). Under open field pest attack was very high and maximum in NS43 (47.5%). All the treatments showed high pest incidence under open field conditions. However, in NS35 (30%) it was slightly lower when compared to the other treatments. The percentage incidence of pest during both seasons is shown in Table 10.

Disease incidence

In nursery stage damping off was noticed for all the treatments but it was controlled. During the off season, disease incidence was more under open field conditions and Disha recorded highest (49.7%) incidence followed by NS35 (48.06%) and was minimum for NS43 (38.81%). Bacterial wilt and fungal rot were observed during off season under open condition. Inside the rain shelter minimum incidence was observed in NS183 (2.5%) followed by Disha (15%), NS43 (17.5%) and maximum in NS35 (25%).

During the main season, no major disease incidence was noticed both under rain shelter and in open field. However, some incidence of *Alternaria* leaf spot was observed both inside and outside rain shelter. The percentage incidence of diseases during both seasons is shown in Table 10.

Table 7. Head length, Head breadth and Core length as influenced by growing condition during main season

Treatment	Head length		Head breadth		Core length	
	Poly house	Open field	Poly house	Open field	Poly house	Open field
T1(NS183)	15.92	14.83	14.67	14.29	8.79	8.46
T2(NS43)	14.67	13.49	15.46	16.62	7.88	6.92
T3(NS35)	15.54	16.91	14.87	17.67	7.87	7.37
T4(Disha)	16.25	15.29	14.58	14.83	9.16	8.33
Mean	15.59	15.13	14.87	15.85	8.43	7.77
CD	1.010		0.922		1.190	

Table 8. Total number of marketable heads, head index and harvest index as influenced by varieties inside the rain shelter during off season.

Treatment	Total number of marketable heads	Head index	Harvest index
T1(NS183)	7.00	1.34	60.465
T2(NS43)	8.75	0.92	67.700
T3(NS35)	8.00	1.12	55.655
T4(Disha)	6.75	1.48	55.010
CD(p<0.05)	NS	0.197	9.755

Table 9. Head index, Harvest index and Total number of marketable heads as influenced by growing conditions during main season

Treatment	Head index		Harvest index		Total no. of marketable heads	
	Poly house	Open field	Poly house	Open field	Poly house	Open field
T1(NS183)	1.09	1.03	66.50	63.25	7.50	7.25
T2(NS43)	0.95	0.82	65.00	67.50	7.75	6.00
T3(NS35)	1.02	0.95	70.75	72.00	7.25	7.75
T4(Disha)	1.11	1.03	60.00	60.00	7.50	7.75
Mean	1.04	0.96	65.56	65.68	7.50	7.18
CD	0.085		5.55		NS	

Table 10. Pest and disease incidence (%) as influenced by growing conditions during off season and main season

Treatment	Pest incidence				Disease incidence			
	Off season		Main season		Off season		Main season	
	Polyhouse	Open field	Polyhouse	Open field	Polyhouse	Open field	Polyhouse	Open field
T1(NS183)	15	19.46	25	45	2.5	46.88	0	0
T2(NS43)	20	24.95	17.5	47.5	17.5	38.81	0	0
T3(NS35)	2.5	16.67	17.5	30	25	48.06	2.5	0
T4(Disha)	7.5	9.47	22.5	42.5	15	49.7	0	2.5

DISCUSSION

During off season, inside the rain shelter the hybrid NS43 was the earliest to form fifty percent heads (52.00 days) and the hybrids failed to form heads in the open field. During on-season also, NS43 was the earliest under both growing conditions while NS35 was late. This can be correlated with the lowest number of non-wrapping leaves recorded in NS43 which is an undesirable trait in cabbage [5].

Suseela [6] reported that there was significant difference in the days to curd formation in cauliflower between the different growing conditions. Curd formation occurred earlier inside the greenhouse conditions. Contradictory to this result, in cabbage, fifty percent head formation was earlier in open field during on-season. Variability in the time of curd initiation or head formation appeared to be mainly a function of time on which the juvenile phase ended [7].

According to Tanaka & Niikura [8] leaf size and plant spread had a relationship between earliness to fifty percent head formation. From table it is clear that NS43 was the earliest and obtained maximum plant spread during off-season. They also suggested that earliness of head formation is highly correlated with the leaf position at which head formation (LPH) started i.e., lower the LPH value, earlier the head formation. However, in some cultivars showed a significant genotypic (G) x environment (E) interaction. Thus, it can be concluded that the seasons or the weather conditions also have an influence on days to fifty percent head formation.

NS43 attained early maturity during both seasons inside rain shelter. While comparing the on-season crop, it was found that open field crop was earlier than rain shelter crop. NS35 was late to mature during on-season under both growing conditions. The early maturing cultivars produce lower yields due to shorter growing season while the late ones give higher yield [9]. Similar results were obtained in the present study also. Under open conditions NS35 produced a gross head weight of 2401.00gm. D'Amato et al. [10] found that late maturing accessions consistently averaged higher yield. Gross head weight is having negative correlation with head compactness and a positive correlation with plant spread [11]. Higher yield of NS35 can be attributed to this. This hybrid also formed very compact heads in open conditions during on season.

Harvest index is a yield attribute which can lead to high yield and it is found to have a direct relationship with yield [12]. It was found to be more for the on season crop due to the favorable climatic conditions which in turn resulted in high biomass production. In the present study, maximum harvest index and net head weight was obtained for the hybrid NS43 during off-season and NS35 during on-season under both growing conditions.

Generally, a short core less than 25 percent of head diameter is preferred. Kleinhenz and Wszalaki [13] noticed that the relationship between head and core volume is a key indicator of crop quality, since the core is removed prior to fresh market consumption or processing. As heads developed a decrease in percentage head volume occupied by the core results in more usable product available to processors and

consumers. In the present study mean core length of outside crop was lower than that of rain shelter crop during on-season.

Pest incidence was more in open field during off and on- seasons. But when compared to off season it was more during on-season. i.e. from October to January. Tobacco caterpillar (*Spodoptera litura*) was the major pest found during both seasons. Similar results were reported by Varalakshmi et al. [14]. They reported that the months of December and January were favorable for the multiplication of *S. litura*. Among the hybrids lowest pest incidence was noticed in NS35 (2.5%) under protected conditions and Disha (9.47%) under open field conditions during off-season. Besides this, leaf webber (*Crocidolomia binotalis*) and painted bug (*Bagrada hilaris*) were also noticed during on-season.

Incidence of disease was very high during off-season under open field conditions disha recorded highest (49.7%) followed by NS35 (48.06%). The high disease incidence during off-season in open field may be due to the high humidity prevailing during the rainy season.

CONCLUSION

It can be concluded that among the F1 hybrids tested NS 43 and NS 35 performed better than others and can be recommended for cultivation in rain shelter and open conditions during on and off seasons respectively. Rain shelter cultivation can be helpful for the farmers to cultivate crops throughout the year especially in places where open field conditions are not favorable due to long monsoon rains.

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