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Influence of environment on growth and bulbing of onion (*Allium cepa*) under Gangetic alluvial plains of West Bengal

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ABSTRACT

The study was set up to investigate the influence of environment on the growth and bulbing of 14 varieties/ cultivars of onion under sub-tropical humid climatic condition of Gangetic alluvial plain of West Bengal. Bulbing in all the 14 varieties/cultivars at 11 hour photoperiod suggested that all the materials could be referred to as tropical and short day varieties/cultivars. Planting of 45 days old seedlings of the selected varieties like, Agrifound Dark Red, Baswant 780, Phule Safed and N-53 in the first week of October and harvesting the bulbs during last week of February has been found to be the best option for growing Early-*Rabi* onion having the projected bulb yield potential of 49-50 tonnes/ha in the agro-climatic condition of West Bengal with average day/night temperature of 21 to 22°C coupled with rainless condition and just above 11 hour photoperiod.

Key words: Bulbing, Day length, Onion, Temperature, Tropical

Onion (*Allium cepa* L.) is one of the important vegetable crops grown in India in large areas both for local consumption as well as for export purposes. Expansion of onion area in sub-tropical humid Gangetic alluvial plain necessitates identification of suitable short day varieties suitable for early cultivation. Onion is a biennial plant and the bulb is the vegetative storage organ of the plant. Onions have a determinate growth habit and at the onset of bulbing, leaf sheaths swell, bladeless bulb scales are initiated and these swell to form the central storage tissue of the bulb. Leaf blades initiated prior to bulbing develop to full expansion and the green top lodges at 'top down'. In temperate and long-day onion cultivars, bulb can be referred as the over-wintering stage in the life cycle of the plant, but in tropical onion cultivars it cannot be said strictly because bulb initiation and maturation sometimes take place within the winter period in the tropical parts of the world.

Bulbing in traditional long-day cultivars of the temperate regions only occurred when dual thresholds of a minimum thermal time of 600 days and a photoperiod of 13.75 hour were reached (Lanchester *et al*. 1996). Short day onion cultivars implies that plant grows and bulbs satisfactorily in less than 12 hour photoperiod. Generally short day onion cultivars are suitable for warm climate hence, tropical onion cultivars are classified as short day onions (Rabinowitch and Currah 2002, Boyhan *et al*. 2001). Machado and do Oliveira (2008) observed that the short-day onion has great agronomical potential in the area having waterlogging problem and low temperature that occur during the growing season.

Although sufficient information are available on long-day temperate onion cultivars with respect to climatic factors including day length, there is paucity of information available on characteristics, production and nature of environmental influence to the tropical onion cultivars (Abubakar 2005) and very little work has so far been done in the subtropical-humid agro-climatic condition of Gangetic alluvial plain of West Bengal. This research, therefore, is intended to find out the influence of environment on the growth and bulbing of 14 tropical onion varieties/cultivars under sub-tropical humid climatic condition in the Gangetic alluvial plain of West Bengal so that suitable variety may be selected for this part of the country.

MATERIALS AND METHODS

The experiments were conducted in two consecutive years (2008-2009 and 2009-2010) at the Central Research Farm, Gayeshpur, Bidhan Chandra Krishi Viswavidyalaya, West Bengal situated at 22°57'N latitude and 88°20'E longitude with an average altitude of 9.75 m above the mean sea level.In the experiment the 14 varieties/cultivars of onion, 13 of which collected from the Directorate of Onion and Garlic Research, Pune–Nasik Highway, Rajgurunagar, Pune, Maharashtra (Phule Safed, Pusa Red, N 53, Arka Kalyan, Gujrat White, Arka Pragati, Agrifound Rose, Agrifound Dark Red, Fursangi Local, Phule Samarth, Aswant 780, Nasik Red and Agrifound Light Red) along

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with "Sukhsagar", the locally adapted cultivar of West Bengal were evaluated in randomized block design with 3 replications for bulb production through three plantings at monthly intervals in the crop durations: September to first week of February (average day/night temperature 29.51°/18.45°C; average 23.98°C; average day length: 11.31 hours), October to last week of February (average day/night temperature 28.76°/16.13°C; average 22.44°C; average day length: 11.19 hours) and November to last week of March (average day/night temperature 29.16°/15.81°C; average 22.48°C; average day length: 11.25 hours). Meteorological data of the cropping period is given in Table 1. In all the three plantings, 45 days old seedlings were transplanted on the first week of September, October and November keeping 100 plants at 15 × 15 cm spacing in the 1.5 × 1.5 m plot.

Top fall over the ground which is the normal maturity index of onion in low rainfall areas did not occur fully in this agro-climatic condition of both the years. Hence, maturity of the bulbs was judged by the growing span, drying of the leaves from the top along with "top fall". After 120 days of growth thickened neck of all the plants were twisted to hasten the drying of the leaves and "top fall" because it did not appear in most of the plants even if irrigation was withdrawn 10 days before harvesting the bulbs. Twenty randomly selected plants per replication (plot) were sampled for recording data on different growth and bulb characters, viz. length of the top (cm), leaves per plant, polar diameter of bulb (cm), equatorial diameter of bulb (cm), bulb weight (g), bulb yield/m^2 (kg) and projected yield (tonnes/ha). Pooled data on bulb yield and its components recorded in three plantings in two consecutive years separately were used for necessary statistical analyses. Analyses of variance were carried out in the form of two-factor analysis (Variety and season) over two years following Gomez and Gomez (1984).

Bulb yield (kg/m^2) recorded in the present investigation has been converted to projected yield in tonnes per hectare after deduction of 25% from the calculated yield flatly keeping in view of loss in net land area due to number of ridges in between plots, irrigation channels and apprehended uneven crop stand in vast stretch of land. Projected yield is basically an extrapolation of actual yield in small area hence, was not included in statistical analyses.

RESULTS AND DISCUSSION

Influence of environment on growth and bulb characters

In this investigation, sufficient bulbing in all the 14 onion varieties/cultivars even at 11 hour photoperiod (September planting) amply suggested that all the materials under study could be referred to as tropical and short day varieties/cultivars. Earlier report of Khokhar (2008) suggested that bulbing in short-day tropical onions could occur at photoperiod even below 11 hour. However, Wiles (1994) concluded that in photoperiods insufficient for bulb initiation, reversion to bladed leaf production will eventually occur however, even in the 8 hour photoperiod, bulb-scale formation continued for some time, particularly in the cultivar with the shortest photoperiod requirement for bulbing, before reversion to bladed leaf production.

Analysis of variance for different growth, bulb characters and bulb yield in three plantings in two years (Table 2) clearly indicated significant differences for all the six characters not only among the varieties but also between year, among the planting time and their interactions. These findings supported varied response of the short-day tropical onion varieties under different temperature and photoperiodic condition. It has long been accepted that day length and temperature play crucial roles in the formation and final size of the bulb however, photoperiod is comparatively more important for bulb formation and temperature is more important for flowering. Onion varieties are generally classified by day length (short, intermediate and long) required for bulbing. However, it cannot be

Table 1 Month wise meteorological data during the experimental period

Year	Temperature (°C)		Total Rainfall	Relative humidity (%)		Day length
	Max.	Min.	(mm)	Max.	Min	(hours)
September 2008	33.21	25.84	234.5	95.47	75.60	12.08
October 2008	32.54	23.20	132.8	93.74	68.26	11.62
November 2008	31.11	18.00	0.0	93.00	51.50	11.15
December 2008	26.56	14.57	0.0	94.94	60.00	10.71
January 2009	26.9	13.6	0.0	94.9	52.8	11.00
February 2009	30.6	14.8	0.0	93.1	38.8	11.46
March 2009	34.3	20.1	67.7	89.2	37.4	11.91
September 2009	32.9	26.3	211.1	95.2	76.8	12.08
October 2009	32.4	22.0	91.1	94.8	63.9	11.62
November 2009	30.3	18.4	0.0	93.3	54.8	11.15
December 2009	26.8	11.8	0.0	93.9	49.4	10.71
January 2010	23.7	9.3	0.0	95.8	51.4	11.00
February 2010	29.6	14.7	7.2	92.1	42.7	11.46
March 2010	35.8	22.4	0.5	89.4	38.5	11.91

Table 2 Analysis of variance for different growth, bulb characters and bulb yield in 3 plantings in 2 years

Source	Mean sum of squares						
	df	No. of leaf/plant	Length of top(cm)	Equatorial diameter(cm)	Polar diameter(cm)	Bulb weight(g)	Bulb yield/ m^2(kg)
Year	1	15.13**	827.32**	12.10**	4.40**	4938.04**	13.31**
Replication	2	42.18**	129.05**	40.96**	41.00**	179.42**	60.15**
Plantings	2	25.61**	1598.99**	0.18**	0.10**	1358.25**	26.76**
Year × Plantings	2	1.23**	168.77**	0.62**	0.09**	398.64**	1.39**
Error	13	1.85	5.28	2.43	2.35	0.16	0.14
Variety	13	11.47**	399.74**	7.03**	3.11**	1417.96**	15.75**
Year × Variety	13	5.83**	95.27**	1.36**	0.76**	131.55**	3.77**
Planting × Variety	26	6.41**	109.49**	0.48**	0.62**	244.62**	3.42**
Year × Planting × Variety	26	1.43**	67.85**	0.24**	0.23**	49.94**	0.24**
Error	26	0.26	1.02	0.15	0.14	0.12	0.11

** Significant at 1% level

suggested flatly that all the tropical and short-day onion varieties will give similar performance across locations in different temperature and photoperiodic regimes. Some earlier studies also recorded significant effects of genotype, environment and genotype × environment on bulb yield of tropical onions (Huh *et al*. 2002, Aklilu 2003). In the present investigation, short day onion cultivars responded to short variations in day length which was also recorded earlier through different studies (Uzo and Currah 1990, Thamburaj and Singh 2003, Okporie and Ekpe 2008).

Irrespective of the varieties, bulb yield increased significantly from 4.55 kg/m^2 (projected yield: 34.12 tonnes/ha) in September planting to 5.57 kg/m^2 (projected yield: 41.77 tonnes/ha) in October and 5.48 kg/m^2 (projected yield: 41.10 tonnes/ha) in November plantings (Table 3) which indicated that moderately low temperature tended to prolong the vegetative phase and thereby increase the size and yield of the bulb which agreed well to the earlier findings of Nanda and Kochhar (1985). In the present investigation, average day/night temperature of 21° to 22°C coupled with rainless condition and just above 11 hour photoperiod has been found suitable for growing early onion under subtropical-humid agro-climatic condition in the Gangetic alluvial plain of West Bengal. Farooqui *et al.* (2005) also suggested earlier that

Table 3 Mean growth, bulb characters and bulb yield of 14 varieties in 3 plantings over two years

Planting	Variety	No. of leaf/plant	Length of top (cm)	Equatorial diameter (cm)	Polar diameter (cm)	Bulb weight (g)	Bulb yield (kg/m^2)	Projected bulb yield (tonnes/ha)
September		8.50	38.89	3.68	3.61	50.30	4.55	34.12
October		8.73	47.57	3.97	3.85	55.12	5.57	41.77
November		8.68	46.02	3.93	3.88	58.29	5.48	41.10
SE ±		0.15	0.25	0.17	0.17	0.12	0.14	
CD (P=0.05)		0.48	0.82	0.56	0.55	0.07	0.07	
	N-53	8.55	46.15	4.26	4.32	57.67	6.05	45.37
	Pusa Red	9.03	51.23	4.26	4.10	52.74	5.27	39.52
	Arka Pragati	7.95	43.41	3.83	3.79	62.50	5.66	42.45
	Arka Kalyan	8.61	40.11	3.93	3.89	54.93	5.01	37.57
	Sukhsagar	7.77	36.12	3.24	4.41	46.95	4.34	32.55
	ADR	8.43	50.38	4.55	3.99	67.41	6.45	48.37
	B-780	8.09	47.19	4.84	4.34	69.88	6.08	45.60
	Phule Safed	9.02	42.78	4.53	3.96	60.72	5.65	42.37
	Phule Samarth	10.08	43.59	4.06	4.23	52.00	4.83	36.22
	Agrifound Rose	7.86	38.65	3.42	3.01	52.05	4.77	35.77
	Fursungi local	8.45	39.53	4.08	3.91	51.89	4.96	37.20
	Gujrat White	7.47	37.23	3.55	3.55	40.06	2.76	20.70
	ALR	6.71	45.91	2.44	3.19	39.70	4.89	36.67
	Nasik Red	8.22	46.63	4.30	3.71	55.48	6.05	45.37
	SEm	0.10	0.24	0.08	0.08	0.09	0.04	-
	CD(P=0.05)	0.29	0.66	0.22	0.22	0.23	0.24	-

12.8° to 21.0°C temperature before bulb formation and 15.5° to 25.0°C for bulb development was found to be ideal for the onion cultivars of India.

Growth and bulb characters of the varieties in three plantings

Variation in mean growth, bulb characters and bulb yield of the 14 varieties/cultivars in three plantings (Table 4) is discussed with the planting time.

September planting : The bulbs were developed and matured under short photoperiod condition. Bulbs of the varieties from this planting were harvested during first week of February under comparatively short day length and low temperature regime. Comparatively high average

Table 4 Interactions between Variety × Planting over two years

Planting × Variety	No. of leaf/plant	Length of top (cm)	Equatorial diameter (cm)	Polar diameter (cm)	Bulb weight (g)	Bulb yield (kg/m^2)	Projected bulb yield(tonnes/ha)
September × N 53	8.24	36.52	4.35	4.75	52.83	5.42	40.65
× Pusa Red	9.14	49.45	4.13	4.52	45.97	5.32	39.90
× Arka Pragati	8.69	38.41	4.05	3.87	53.17	4.62	34.65
× Arka Kalyan	10.43	34.26	3.77	3.62	47.25	3.81	28.57
× Sukhsagar	7.69	31.22	2.98	3.81	33.76	2.45	18.37
× ADR	7.75	47.63	4.54	4.27	66.74	5.79	43.42
× B-780	7.07	42.71	5.24	4.74	69.52	5.11	38.32
× Phule Safed	8.20	34.37	4.76	4.07	45.67	3.62	27.15
× Phule Samarth	12.26	39.22	3.92	3.75	51.25	4.84	36.30
× Agrifound Rose	7.93	35.47	3.33	3.00	51.25	4.55	34.12
× Fursungi local	9.73	34.89	4.21	3.96	51.97	4.72	35.40
× Gujrat White	6.69	27.68	3.63	3.62	41.01	2.45	18.37
× ALR	6.75	46.91	2.45	3.18	38.06	4.84	36.30
× Nasik Red	8.41	45.73	4.31	3.62	55.77	6.15	46.12
October × N 53	8.77	50.39	4.31	4.45	64.44	6.65	49.87
× Pusa Red	9.68	55.20	4.55	4.35	62.61	6.44	48.30
× Arka Pragati	7.98	54.05	3.46	3.72	65.34	6.08	45.60
× Arka Kalyan	9.19	44.53	3.64	3.98	46.50	5.07	38.02
× Sukhsagar	7.48	37.54	3.18	4.35	48.34	5.26	39.45
× ADR	9.47	50.35	5.06	4.52	66.44	6.78	50.85
× B-780	8.66	48.72	4.84	4.36	67.57	6.77	50.77
× Phule Safed	9.25	52.08	4.63	3.98	65.32	6.57	49.27
× Phule Samarth	9.94	48.26	4.16	4.41	47.92	4.55	34.12
× Agrifound Rose	8.40	39.30	3.23	2.69	49.67	4.67	35.02
× Fursungi local	9.54	49.90	4.21	3.84	55.82	5.77	43.27
× Gujrat White	8.42	40.08	3.78	3.66	41.83	2.44	20.30
× ALR	7.08	47.08	2.41	3.20	40.31	4.99	37.42
× Nasik Red	8.40	48.46	4.31	3.60	55.57	5.93	44.47
November × N 53	8.64	51.53	4.12	4.15	61.75	6.08	45.60
× Pusa Red	8.27	49.05	4.08	3.73	49.63	4.06	30.45
× Arka Pragati	7.18	37.78	4.91	3.98	68.99	6.28	47.10
× Arka Kalyan	6.20	41.53	4.59	4.47	71.03	6.16	46.20
× Sukhsagar	8.14	49.57	3.56	4.67	58.74	5.31	39.82
× ADR	8.07	53.17	4.98	4.34	69.86	6.77	50.77
× B-780	8.55	52.14	4.78	4.23	72.55	6.37	47.77
× Phule Safed	9.62	41.91	4.83	4.36	71.17	6.77	50.77
× Phule Samarth	8.05	43.31	4.12	4.53	56.83	5.10	38.25
× Agrifound Rose	7.26	41.17	3.70	3.34	55.23	5.10	38.25
× Fursungi local	6.09	43.80	3.82	3.93	47.88	4.40	33.00
× Gujrat White	7.30	43.92	3.23	3.38	37.33	3.41	25.57
× ALR	6.31	43.75	2.46	3.19	40.73	4.83	36.22
× Nasik Red	7.84	45.71	4.29	3.90	55.09	6.06	45.45
SE±	0.18	0.41	0.13	0.14	0.14	0.07	
CD(P=0.05)	0.50	1.14	0.37	0.38	0.39	0.19	

ADR, Agrifound Dark Red; ALR, Agrifound Light Red; B 780, Baswant 780

temperature (average day/night temperature 29.51°/18.45°C; average 23.98°C; average day length: 11.31 hours, high average relative humidity (95.22%), and high rainfall during first 90 days, including last 30 days in seed bed (average 229.52 mm during August to October) were the main environmental features of this season. All the varieties responded significantly for bulb production. The highest yielding variety was Nasik Red (6.15 kg/m^2 ; projected yield: 46.12 tonnes/ha) followed by Agrifound Dark Red (5.79 kg/m^2; projected yield: 43.42 tonnes/ha), N 53 (5.42 kg/m^2; projected yield: 40.65 tonnes/ha) and Pusa Red (5.32 kg/m^2; projected yield: 39.90 tonnes/ha).

October planting: The bulbs were developed and matured under comparatively high photoperiodic regime. Bulbs of the varieties from this planting were harvested during last week of February under rising day length and somewhat enhanced average temperature. Comparatively low average temperature with respect to September planting (average day/night temperature 28.76°/16.13°C; average 22.44°C; average day length: 11.19 hours, low average relative humidity (66.1%) and low rainfall first 90 days, including last 30 days in seed bed (average 140.06 mm during September to November) were the main environmental features of this season. The highest yielding variety for this season was Agrifound Dark Red (6.78 kg/m^2 ; projected yield: 50.85 tonnes/ha) followed by Baswant 780 (6.77 kg/m^2; projected yield: 50.77 tonnes/ha), N 53 (6.65 kg/m^2; projected yield: 49.87 tonnes/ha) and Phule Safed (6.57 kg/m^2; projected yield: 49.27 tonnes/ha).

November planting: The bulbs were developed and matured under high photoperiod condition. Bulbs of the varieties from this planting were harvested last week of March under comparatively long day length and moderately high temperature regime. Average temperature regime was the lowest in November planting (average day/night temperature 29.16°/15.81°C; average 22.48°C; average day length: 11.25 hours, low average relative humidity (56.1%) and very little rainfall in first 90 days, including last 30 days in seed bed (average 41.77 mm during October to December) were the main environmental features of this season. The highest yielding variety for November planting was Phule safed and Agrifound Dark Red (6.77 kg/m^2 ; projected yield: 50.77 tonnes/ha) followed by Baswant 780 (6.37 kg/m^2; projected yield: 47.77 tonnes/ha) and Arka Pragati (6.28 kg/m^2; projected yield: 47.10 tonnes/ha).

Best growing season of Early Rabi onion in West Bengal

In the sub-tropical humid climatic condition of Gangetic alluvial plain of West Bengal , onions are traditionally grown in *rabi* season (December-January to April-May) and harvesting of bulbs are often clashed with the pre-monsoon shower leaving the weather condition as well as the matured crop unsuitable for storage. It emerged from the present investigation that average day/night temperature of 21° to 22°C coupled with rainless condition and just above 11 hour photoperiod was suitable for growing early onion in the subtropical humid condition in the Gangetic alluvial plain of West Bengal. The present investigation also justified the possibility of growing Early-*Rabi* onion even by September planting employing the tropical short-day varieties like, Nasik Red, Agrifound Dark Red, N 53 and Baswant -780. Two earlier studies in West Bengal and Odisha also suggested Agrifound Dark Red and Baswant 780 as the best varieties for growing onion early in the season (Mohanty *et al*. 2001, Giri *et al*. 2009).

However, in order to avoid high precipitation during the first 60 days of the crop growth which causes high seedling mortality and consequently slow down growth, planting of seedlings of the selected varieties like, Agrifound Dark Red, Baswant 780, Phule Safed and N 53 in the first week of October and harvesting the bulbs during last week of February has been found to be the best option for growing Early-*Rabi* onion in this sub-tropical humid climatic condition. It would be ideal to have appreciable bulb yield during dry and less humid period of last week of February-March so that span of bulb storage in ambient condition can be lengthened.

Conclusion

Bulbing in all the 14 varieties/cultivars occurred at 11 hour photoperiod which classified these materials under short day category. Planting of 45 days old seedlings of the selected varieties like, Agrifound Dark Red, Baswant 780, Phule Safed and N 53 in the first week of October and harvesting the bulbs during last week of February has been found to be the best option for growing Early-*Rabi* onion having the projected bulb yield potential of 49-50 tonnes/ha in the agro-climatic condition of West Bengal with average day/night temperature of 21 to 22°C coupled with rainless condition and just above 11 hour photoperiod.

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