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RESEARCH ARTICLE

EFFECT OF WATERLOGGING ON YIELD ATTRIBUTES OF CHILLI

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ABSTRACT

Waterlogging is a serious abiotic stress for chilli production. To find out adverse effect of waterlogging on yield attributes of chilli a pot experiment was conducted on jute agriculture experimental station, Bangladesh Jute Research Institute, Jagir, Manikganj. Yield attributes varied significantly due to waterlogging stress. All yield characters perform better at no waterlogging condition whereas the lowest yield characters perform at 12 days of waterlogging condition. Thirty days old healthy chilli plants were subjected to continuous flooding stress of different durations 0, 3, 6, 9 and 12 days. Earthan pots healthy chilli plants were placed inside a larger concrete chamber and irrigated with tap water so that the waterlogging depth was maintained within 4-5 cm throughout the experimental period. Height of plant, leaf number, diameter of stem base, area of leaf, days to flowering and fruits umber per plant were recorded.

KEYWORDS

Chilli, flooding stress, growth parameters, and yield attributes

1. INTRODUCTION

Chilli (Capsicum annum L.) belongs to the family of Solanaceae which is widely used as spice and as vegetable. Chilli (marich) pod of a bushy plant, *Capsicum frutescens* is native of Mexico. Chilli is a good source of vitamins and phosphorus. This crop is widely cultivated in Bangladesh. As a winter crop chilli is grown mostly in Comilla, Noakhali, Faridpur, Barisal, Patuakhali, Bogura and other regions of Bangladesh. Chilli is consumed as spice and vegetable all over the world. Almost one-fourth of the total population of the world consumes chilli and it's one of the most important component which is used in cuisines (Nabhan et al 2011). Chilli is not only a spice and vegetable it also count as cash crop in Bangladesh. According to Molla et. al., (2022), chilli cultivated area was 19000 ha and total production of chilli was 36,000 t in summer season and in winter season chilli cultivation and production were three times higher than summer season. The yield was around 1.42 t ha^{-1} (BBS, 2019). In chilli, more than 200 active constituents have been found and some of its active constituents play numerous beneficial roles in various gastrointestinal disorders such as stimulation of digestion, reduction of gastro esophageal reflux disease (GERD) symptoms, inhibition of gastrointestinal pathogens, ulceration and cancers, regulation of gastrointestinal secretions and absorptions (Maji and Banerji, 2016). The medicinal properties are attributed to cure of skin problems and bodies with scars, grains and use to stop bleeding using toasted fruit (Ganguly *et. al.*, 2017).

The term waterlogging is now the matter of global concern and one of the most mooted abiotic stress which responsible for the reduction of crop growth and yield (Linkemer *et al.*, 1998; Setter and Waters, 2003; Lone *et al.,* 2018). Due to the change of the climate the water level is increasing day by day and the waterlogging events are becoming severe and unpredictable (Jackson and Colmer 2005). 16% of the soils in USA and 10% of the agricultural lands of Russia and irrigated crop production areas of India, Pakistan, Bangladesh, and China were affected due to waterlogging conditions (Yaduvanshi et al., 2014; FAO, 2015). Heavy and continuous rainfall and lack of quality drainage are the main reasons for waterlogging (Hasanuzzaman *et al.,* 2012a). Under waterlogging condition plants suffer from the scarcity of available O_2 (Capon et al., 2009). Hypoxia (lack of O_2) is the primary phase of waterlogging that limits the mitochondrial respiration, followed by anoxia (inhibited respiration results from O_2 deficiency) (Wegner, 2010).

Chilli growers in all over the world have been suffering crop losses owing to incessant rains causing waterlogging and rampant pest attacks that followed the wet spell (Anonymous 2022). Due to shallow root systems chilli is very sensitive to waterlogging and water stress may cause a dramatic reduction in their desired production. Under waterlogged conditions, it has been estimated that soils diffuse oxygen at a rate 10^4 times slower than air, and the process of respiration by roots of plants and soil microbes rapidly exhausts oxygen levels, causing plants to undergo various morphological, metabolic, physiological, and transcriptional changes (Narsai *et al.,* 2009, Zou *et al.*, 2010). Waterlogging conditions are responsible for the reduction in both root and shoot dry matter, root volume, leaf area, transpiration and leads to poor grain yield (Fageria *et al*., 2006, Zaidi *et al.,* 2004). From the above discussion, it summarized that the experiment was undertaken to evaluate the waterlogging effect on growth and yield of chilli.

2. MATERIALS AND METHODS

To find out the waterlogging effects on growth and yield of chilli an experiment was conducted at Jute Agriculture Experimental Station, BJRI, Manikganj during the period from September to December, 2020. The

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chilli cultivars were raised in pot and different waterlogging treatments were applied on it. 1% $HgCl_2$ solution was used to sterilized the chilli cultivars. Twenty-five seeds were sown per pot (15 inches in height and 16 inches in diameter) containing 40 kg soil. The atmospheric temperature fluctuated within a range of 29-31 ^{0}C at day and 18-27 ^{0}C at night. The relative humidity fluctuated between 71% and 83% at day and night, respectively. Waterlogging induced at 30 DAG (Days after germination). Three chilli varieties1= Bizly plus; 2= Red gold; 3= Hot king with five different i.e. 0, 3, 6, 9 and 12 days of waterlogging were used as treatments. Waterlogging depth was 4-5cm from the base of the plant. Crop was harvested at the period of horticultural maturity. Completely Randomized Design (CRD) with a two factors and three replications were used in this experiment. 3 pots with 15plants were considered as a replication in which each pot contained 5 plants. The collected data on different growth and yield related characters were subjected to statistical analysis following ANOVA technique. Differences among treatment means were adjusted by Duncan's Multiple Range Test with the help of a computer based statistical package program MSTAT-C (Gomez and Gomez, 1984).

3. Result and Discussion

3.1 Plant height

Plant height varied significantly among different genotypes (Figure 1). The highest plant height was found in 'Red gold' variety and the lowest was found in 'Bizly plus' variety which was statistically identical with 'Hot king' variety. On the other hand plant height was significantly different among different waterlogging treatments (Table 1). The highest plant height was recorded in 0 days of waterlogging and the lowest plant height was recorded in 12 days of waterlogging and it was recorded that plant height was decreased with increasing waterlogging stress. Furthermore plant height was significantly different among different interactions (Table 2). The maximum plant height was recorded in Bizly plus X 0 days of waterlogging interaction which was statistically identical with Hot king X 0 days of waterlogging interaction and the lowest plant height was recorded in Bizly plus X 12 days of waterlogging. Other treatments remain in the middle position.

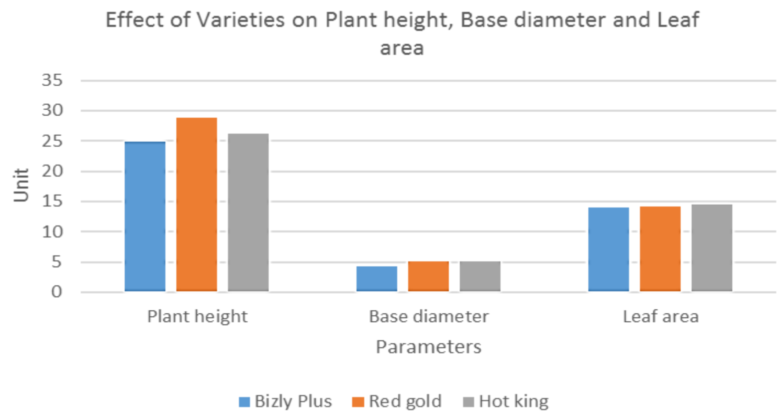

Figure 1: Varietal effect of morphological characters (plant height, base diameter, leaf area) of chilli

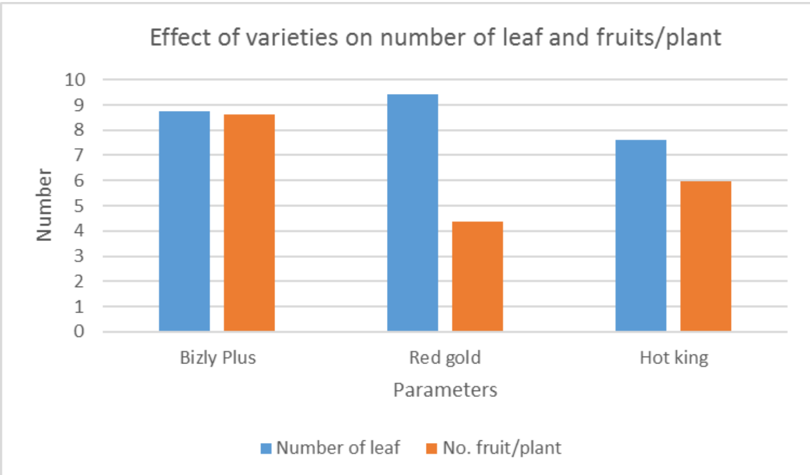

Figure 2: Varietal effect of morphological characters (number of leaf, number of fruits/plant) of chilli

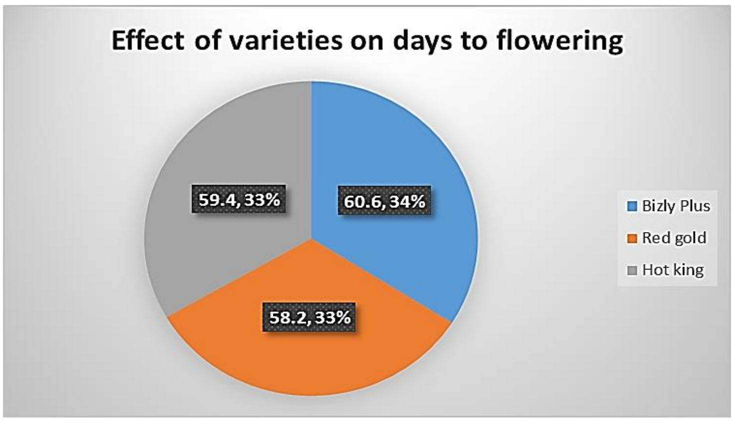

Figure 3: Varietal effects on different flowering days

Table 1: Effect of waterlogging on yield attributes of chilli						
Waterlogging (days)	Plant height	Number of leaf	Base diameter	Leaf area	Days to flowering	No. fruit/plant
0	39.401a	13.222 a	5.8511 a	28.013a	46.45d	10.757a
3	30.467b	11.000 b	5.2811 ab	15.639 b	53.44c	8.441b
6	22.704c	7.444 c	4.8578 bc	9.871c	61.22b	6.127c
9	21.38cd	6.222 d	4.3989 cd	9.332c	66.44a	4.213d
12	19.18d	5.000 e	3.9767 d	8.300d	69.44a	2.031e
CV(%)	10.58	10.13	13.41	6.87	5.61	12.44
LSD	2.721	0.8394	0.6308	0.9440	3.2181	0.7583

3.2 Number of leaf

Number of leaf varied significantly among different genotypes (Figure 2). The highest number of leaf was found in ‘Red gold’ variety and the lowest was found in ‘Hot king’ variety and the variety ‘Bizly plus’ remain in the middle position. On the other hand number of leaf was significantly different among different waterlogging treatments (Table 1). The highest number of leaf was recorded in 0 days of waterlogging and the lowest number of leaf was recorded in 12 days of waterlogging and it was recorded that number of leaf was decreased with increasing waterlogging stress. Furthermore number of leaf was significantly different among different interactions (Table 2). The highest number of leaf was recorded in Red gold X 0 days of waterlogging interaction and the lowest number of leaf was recorded in Hot king X 12 days of waterlogging which was statistically identical with Bizly plus X 12 days of waterlogging interaction. Other treatments remain in the middle position.

3.3 Base diameter

Base diameter varied significantly among studied genotypes (Figure 1). The highest base diameter was found in ‘Red gold’ variety which was statistically identical with ‘Hot king’ variety and the lowest was found in ‘Bizly plus’ variety. On the other hand base diameter was significantly different among different waterlogging treatments (Table 1). The highest base diameter was recorded in 0 days of waterlogging and the lowest number of leaf was recorded in 12 days of waterlogging and it was recorded that base diameter was decreased with increasing waterlogging stress. Furthermore base diameter was significantly different among different interactions (Table 2). The highest base diameter was recorded in Hot king X 0 days of waterlogging interaction and the lowest base diameter was recorded in Bizly plus X 12 days of waterlogging. Other treatments remain in the middle position.

3.4 Leaf area

Leaf area of studied genotypes were statistically non-significant (Figure 1). On the other hand leaf area was significantly different among different waterlogging treatments (Table 1). The highest leaf area was recorded in 0 days of waterlogging and the lowest leaf area was recorded in 12 days of waterlogging and it was recorded that leaf area was decreased with increasing waterlogging stress. Furthermore leaf area was significantly different among different interactions (Table 2). The highest leaf area was recorded in Red gold X 0 days of waterlogging interaction which was statistically identical with Hot king X 0 days of waterlogging interaction and Bizly plus X 0 days of waterlogging interaction; and the lowest leaf area was recorded in Red gold X 12 days of waterlogging. Other treatments remain in the middle position.

3.5 Days to flowering

Days to flowering of studied genotypes were statistically non-significant (Figure 3). On the other hand days to flowering was significantly different among different waterlogging treatments (Table 1). The highest days to flowering was recorded in 12 days of waterlogging and the lowest days to flowering was recorded in 0 days of waterlogging and it was recorded that days to flowering was increased with increasing waterlogging stress. Furthermore days to flowering was significantly different among different interactions (Table 2). The highest days to flowering was recorded in Hot king X 12 days of waterlogging interaction which was statistically identical with Bizly plus X 12 days of waterlogging interaction and Red gold X 12 days of waterlogging interaction; and the lowest days to flowering was recorded in Red gold X 0 days of waterlogging. Other treatments remain in the middle position.

3.6 Number of fruits per plant

Number of fruits per plant varied significantly among studied genotypes (Figure 2). The highest number of fruits was found in ‘Bizly plus’ variety and the lowest was found in ‘Red gold’ variety. The variety ‘Hot king’ remain in the middle position. On the other hand number of fruits per plant was significantly different among different waterlogging treatments (Table 1). The highest number of fruits was recorded in 0 days of waterlogging and the lowest number of leaf was recorded in 12 days of waterlogging and it was recorded that number of fruits was decreased with increasing waterlogging stress. Furthermore number of fruits was significantly different among different interactions (Table 2). The highest number of fruits was recorded in Bizly plus X 0 days of waterlogging interaction and the lowest number of fruits was recorded in Hot king X 12 days of waterlogging. Other treatments remain in the middle position.

Table 2: Effect of variety X treatment interaction on yield attributes of chilli						
Variety X Treatment	Plant height (cm)	Number of leaf	Base diameter (mm)	Leaf area (cm^2)	Days to flowering	Number of fruits/plant
1x1	41.217a	12.667b	5.6533a-c	27.403a	48.33f-h	12.887a
1x2	27.577de	11.0cd	4.64c-g	15.153b	55.33de	11.223b
1x3	20.75fgh	8.0 e	4.083f-h	9.563cd	63.33bc	9.053c
1x4	19.217ghi	7.33ef	3.8167gh	9.163cd	66.67ab	6.120d
1x5	15.593i	4.667h	3.4600h	8.583cd	69.33a	3.793e
2x1	37.867ab	15.00a	5.7800ab	28.517a	44.33h	8.833c
2x2	33.373bc	12.0bc	5.753ab	15.103b	51.67e-g	6.250d
2x3	24.933ef	7.333ef	5.37 a-e	9.920 c	59.67cd	3.88e
2x4	24.243ef	6.333fg	4.49d-h	9.383cd	66.33ab	2.40f
2x5	23.397efg	6.33fg	4.310e-h	8.167d	69.00a	0.500g
3x1	39.12a	12.000bc	6.120a	28.12a	46.67gh	10.55b
3x2	30.45cd	10.0d	5.45a-d	16.66b	53.33ef	7.850c
3x3	22.43fgh	7.000ef	5.12 a-f	10.130c	60.67cd	5.450d
3x4	20.68fgh	5.000 gh	4.89b-g	9.450cd	66.33ab	4.120e
3x5	18.55hi	4.000 h	4.160f-h	9.450cd	70.00a	1.80fg
CV(%)	10.58	10.13	13.41	6.87	5.61	12.44
LSD	4.7129	1.4538	1.0926	1.635	5.574	1.3134

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4. Discussion

Chilli, an important spice and vegetable which is very much sensitive to waterlogging condition (Molla *et. al.,* 2022). The scarcity of oxygen is one of the major problem which is caused due to the waterlogging (Armstrong, 1979; Jackson and Drew, 1984; Kozlowski, 1984). Chilli roots absorb oxygen from the air pockets of the soil. The anoxic condition is created when the roots of chilli submerged in water for long time and this condition obstruct the root development that's why shoot and plant productivity also reduce (Tareq *et al.*, 2020).

Due to the waterlogging condition the morphological characters like plant height, number of leaf, base diameter of chilli, leaf area of chilli are adversely differ from control condition. Limitation of nitrogen supply and enhanced ethylene production in waterlogging condition are responsible for the leaf growth reduction (Adhikari and Paje, 1993).

Reduction of photosynthetic rate could be one of the most important reasons behind the negative effect of flooding in morphological attributes of chilli. Due to the waterlogging condition the plant growth reduction was also noticed in Annona species, *Panicum antidotale*, *Paspalum dilatatum* and tomato (Nunez-Elisea, 1999; Ashraf, 2003; Vasellati, 2001; Walter, 2004; Ezin et al., 2010).

Waterlogging experiments have been conducted in many other crops and the findings of the results of the present study were very much close to other experiments. Experiment conducted by Kim et. al., 2018 and Cardoso et. al., 2014 in soybean and *Brachiaria humidicola* were found that the root surface area of control plants were significantly higher than wterlogged plants. The past literature revealed the reduction in lateral roots under waterlogged conditions in some accessions of *Brachiaria humidicola*, pea, rice, banana and sorghum (Cardoso et al 2013; Armstrong et al., 1983; Ota, 1970; Aguilar et al., 2003; Pardales et al., 1991).

This study revealed that retrenchment of photosynthetic activities and the worsened flooding effect are responsible for significant yield reduction. According to Kramer (1951) the toxic elements like nitrites and sulphides which are produced under anaerobic conditionare responsible for the dead of plant (Kramer, 1951). According to Kozlowski (1997) anaerobic condition is responsible for the disturbance of flower bud initiation, flowering period of a plant and fruit development of different plants (Kozlowski, 1997). Ezin et al., (2010) reported that, time and duration of flooding are responsible for the variation of reproductive growth of plants (Ezin et al., 2010).

5. Conclusion

This research findings revealed that, waterlogging is responsible for the reduction of the morphological attributes of chilli. According to the results these varieties should not be cultivated in the flood prone areas. This experiment will be helpful for the researchers specially breeders to develop high yielding water tolerant chilli varieties.

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