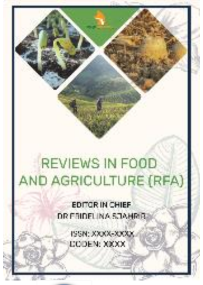
ZIBELINE INTERNATIONAL PUBLISHING

Reviews in Food and Agriculture (RFNA)

DOI: http://doi.org/10.26480/rfna.02.2021.73.75

ISSN: 2735-0312 (Online)
CODEN: RFAEAW



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REVIEW ARTICLE

EFFECT OF DROUGHT ON WHEAT IN NEPAL

Sansar Sahani*, Sandesh Shrestha*, Tilak Ram Bhusal, Nabaraj dwadi, Rajesh Kumar Gupta, Prabin Sharma, Chetan Khanal, Mukti Ram Poudel*

Institute of Agriculture and Animal Science (IAAS), Paklihawa Campus, Rupandehi, Nepal.
****Corresponding Author Email: shresthasandesh1227@gmail.com***

ARTICLE DETAILS

Article History:

Received 05 April 2021
Accepted 08 May 2021
Available online 21 May 2021

ABSTRACT

Wheat is most cultivated cereal of Nepal after rice and maize because of its multiple uses. Wheat is staple food for many developing countries. Whatever it's uses, the yield loss has become one the important concern for today's breeders and researchers. In Nepal, wheat is grown under rainfed condition and hence, is more susceptible to drought. Drought stress plays significant role in yield loss. During the course of phenological cycle, the crop evapotranspiration increases and reaches a maximum in the growth stage (from the beginning of heading to the end of flowering), which is the most sensitive stage of the wheat crop to drought. Drought brings various morphological, physiological, biochemical, genetics variations which has direct or indirect correlation with yield. Many researchers and breeders are working to develop drought tolerant genotypes to withstand drought Wheat breeding programs aim to reorganize genotypes possessing improved yields adaptation to changing climatic conditions and a balanced food quality.

KEYWORDS

Phenological, genetics variations, genotypes.

1. INTRODUCTION

Wheat is an annual grass growing to between 0.5 to 1.25 meters in height with a long stalk that terminate in a tightly formed cluster of plump kernels enclosed by beard of bristly spikes (Smith, 2010).Wheat is widely grown and consumed food grain of the world (Farooq et al., 2011). The 3.5 ounces (100 grams) of whole-grain wheat flour 340 Calories**,** 11% water ,13.2 grams protein, 72 grams carbs, 0.4 grams sugar 10.7 grams fiber and 2.5 grams fat are present (Food Data Central, 2019.) Wheat grains are used for bread, pasta, cakes, noodle, biscuits, Marconi etc. Approximately, one-third of the global population uses wheat as a staple crop and also the first cereal crop in majority of the developing countries (Bayoumi, 2009). In the marketing year of 2019/2020, the global production volume of the wheat amounted over 765 million metric tons (Shahbandeh,2021). In 2020, wheat production for Nepal was 2210 thousand tons and wheat production increase from 193 thousand tons in 1971 to 2210 thousand tons in 2020 growing at an average annual rate of 5.73% (World Data Atlas) in Nepal.

Crop growth and development are influenced by environmental conditions like stresses which are the most crucial yield reducing factor in the world (Dennis, 2000). With increasing global climatic change and shortage of water resources and worsening eco-environment, wheat production is influenced greatly (Singh and chaudhary, 2006). The scarcity of water which induces gradual morphological, biochemical, physiological and molecular changes is called as drought stress (Sallam et al., 2019). Drought stress is one of the crop performance reducing factors and create a problem for successful crop production. Drought is natural unpredictable phenomenon (Mukherjee et al., 2018) whereas it is influenced by anthropogenic factor and changing climate (Mishra and Singh, 2010; Sheffield et al., 2012). Regular climate change has accelerated and increased many severe weather condition like drought and flood (IPCC, 2012; Leng et al., 2015; Haile et al., 2020b), with substantial regional variation. An agricultural drought is a complex and less understood problem (Mishra and Singh, 2010; Dai, 2011). Drought creates an environmental disturbance in which the moisture in the soil becomes insufficient for plant growth and leads to crop yield failure and food insecurity (Fahad et al., 2017; Mao et al., 2017; Haileet al., 2020a). Drought is most devastating stress in wheat crop which affects morphological, physiological, biochemical, and molecular characteristics and results in extreme reduction in production (Nezhadahmadi et al., 2013; Bila et al., 2015). The impacts of agricultural drought are notably higher in Nepal due to more dependence on rainfed farming agriculture (Miyan, 2015; Chen et al., 2016; Potopovaet al., 2016). Thus, region-specific explorations of agricultural drought are important for effective (Rijal et al., 2021) and efficient drought monitoring and adaptation strategies to overcome drought hazard. Drought has occurred frequently in past decade mainly influenced by climate change (Wang et al., 2013). Due to the existing climatic change, it is assumed that by the year 2025, around 1.8 billion people will face absolute water lacking and 65% of the world's population will live under water-stressed environments (Nezhadahmadi, 2013).The production and area under wheat in Nepal is tabulated below.

Quick Response Code	Access this article online	
	Website: www.rfna.com.my	**DOI:** 10.26480/rfna.02.2021.73.75

Cite the Article: Sansar Sahani, Sandesh Shrestha, Tilak Ram Bhusal, Nabaraj dwadi, Rajesh Kumar Gupta, Prabin Sharma, Chetan Khanal, Mukti Ram Poudel (2021). Effect of Drought on Wheat in Nepal. *Reviews in Food and Agriculture, 2(2): 73-75*.

Year	Area (ha)	Yield (Mt/ha)
2009/10	731131	2.13
2010/11	767499	2.27
2011/12	765317	2.41
2012/13	759843	2.48
2013/14	754474	2.50
2014/15	762373	2.59
2015/16	745823	2.33
2016/17	735850	2.55
2017/18	706843	2.76
2018/19	703992	2.85

Source: MOAD, "Statistical information on agriculture agribusiness promotion and stastistics division agrostastics section Singh durbar Kathmandu Nepal, 2020"

1.1 Morphological changes due to drought

There occur various morphological changes in wheat crop which can be observed directly throughout the different stages of plant growth. Generally, the morphological response of wheat can be categorized into two parts i.e. shoot part and root part. The shoot part contains changes in leaf shape, leaf expansion, leaf size, leaf area, leaf senescence, leaf waxiness, cuticle tolerance, leaf pubescence and reduction in shoot length. Whereas, the lower root part includes changes in root dry weight, root density, and root length (Denčić et al., 2000). Several research have shown that the correlation between morphological traits such as grain yield per plant, grain spike per plant, spike fertility and plant height were considered as a trustable indicator for screening drought tolerant wheat cultivars. Researchers found the positive correlation between leaf area, plant height and grain yield. Finally, the morphological changes like decreased plant size, early maturity, decreased leaf area, reduced yield, limited leaf extension, small leaf size, reduced number of tillers, reduced leaf longevity, reduced total shoot length, decreased plant height, increased in leaf rolling and reduction in plant biomass in wheat as a response to drought stress.

1.2 Response towards drought stress

According to Doorenbos and Kassam (1979), wheat crops requires a water requirement ranges from 450 to 650 mm; over its entire cycle starting from 95 to 125 days. When plants face drought stress, they close their stomata to stop dehydration. The absorption and water loss within the guard cells changes their turgor and modulate the opening and closing of the stomata, through hydropassive (without energy expenditure) and hydroactive (with energy expenditure) movements. With the closing of the stomata, there is drastic reduction in transpiration rates, because 80% of the plant's transpiration is stomatal, with the rest performed by the cuticle ((Taiz and Zeiger, 2017)). When undergoing drought stress, plants increase the assembly of abscisic acid by the maximum amount as 50-fold in leaves, which decreases leaf area because of lower-turgor-pressure cells, stomatal closure, the induction of senescence and ethylene production (Taiz and Zeiger, 2013). The water deficit starts a sophisticated pathway response, starting with the perception of stress triggering a sequence of metabolic pathways. This may end in various physiological responses both metabolic and developmental. A change within the osmotic potential, relative to the semipermeable membrane, may be a significant reason behind response to water stress at the molecular level (Bray, 1993)

High temperature increases respiration, photosynthesis and enzyme activity within the plant. In drought condition, the light reaction of photosynthesis continues production of excess free radicals of oxygen which ends to plant death. Drought reduced the nutrient absorption from the upper soil horizon. ((Bagheri, 2009). With increase in drought conditions, accumulation of salts and ions within the upper layers of the soil round the root cause osmotic stress and ion toxicity. The primary response to fret could be a biophysical response. In fact, with increasing drought stress, cell wall shrink and loose, with a decrease in cell volume, pressure decreases and therefore the potential for the development of the cell, counting on the potential pressure decreases and growth is reduced. These factors are the dimension and number of leaves in plants (Bagheri, 2009). Leaf mesophyll cells become dehydrated because of drought. The quantity of abscisic acid had to be stored within the chloroplasts in the guard cells and also the construction of ABA in guard cells and mesophyll increased. With the rise of ABA, potassium and calcium ions go out of the guard cell. The result of this process is stomatal closure, with the loss of water within the guard cell. Lack of water, the speed of photosynthesis in plants decreases. This can be because of the decrease of photosynthetic enzymes. The shortage of water, causing discoloration and leaf trichomes and stomata on the leaf surface is increased. In conditions of severe water shortage, the roots will shrink and in the leaves induce ABA deposition (Bagheri, 2009)

1.3 Biochemical response of wheat towards drought

The resistance of plants to drought is incredibly complex, and its expression depends on the action and interaction of various morphological (reduced leaf area, leaf roll, wax content, efficient root system, and yield stability), physiological (reduction in transpiration, high efficiency in water use, stomatal closure, and osmotic adjustment), and biochemical (proline accumulation, polyamines, diamine, increased nitrate reductase activity and increased carbohydrate storage) characteristics. However, knowledge about the genetic mechanisms that influence these traits continues to be less (Mitra, 2001; Fumis and Pedras, 2002). The synthesis of proteins under stress conditions is decreased and their degradation is accelerated, which ends within the accumulation of free amino acids and amines (Larcher, 2000). The hallmark of a disorder in protein metabolism is that the change within the proportion of amino acids, and a high concentration of proline (Larcher, 2000). Usually, when plants are exposed to various types of environmental stress, notably water, they will accumulate proline, putrescine, and polyamines (Fumis and Pedras, 2002). The assembly of these compounds in water deficit has been related to the tolerance of plants on the unfavorable condition, and will represent a regulatory mechanism of water loss through increased cellular osmolarity (water potential) (Rodrigues et al., 1998; Fumis and Pedras, 2002; Marin et al., 2006). Additionally, the buildup of proline as a compatible osmolyte, during and between periods of stress, is well documented (Shevyakova, 1984; Hare and Cress, 1997; Carceller et al., 1999; LazcanoFerrat and Lovatt, 1999; Mitra, 2001; Kishor et al., 2005). The identification of genotypes that are tolerant to environmental stresses through classical breeding methods is difficult, because it is a characteristic with low heritability and is typically a genotype ×environment interaction. This is often additionally to the choice process usually occurring in differing conditions (Smith et al., 1990; Kirigwi et al., 2004). Thus, plant transformation has been demonstrated as an option for the development of wheat genotypes that are tolerant to drought, and are therefore more productive (Sahrawat et al., 2003). Techniques for the genetic transformation of plants are utilized in identifying genes answerable for their resistance to drought, additionally the transfer of those plant genotypes (Grover et al., 2001). Studies have shown that the manipulation of genes answerable for the biosynthesis of low-molecular-weight metabolites has resulted in plants with an increased tolerance to drought

1.4 Wheat production affected by drought

Water is becoming scarce for wheat crop in South Asia as less water recharge from rainfall (Singh, 2000). Moisture stress is one amongst the key abiotic factors limiting wheat production worldwide (Richards et., 2001). Wheat is usually cultivated under rainfed conditions where fluctuations in rainfall pattern have caused water insufficiency to act as a determining factor for declining the crop yield, especially when water deficit stress occurs during the flowering and grain filling period stages (Bassi et al., 2017). Approximately 65 million ha of wheat production was full of drought stress in 2013 (Nations, 2020). In an exceedingly survey that covered 102 million hectares of wheat area within the developing countries (47% global wheat area or 89% of the wheat area in developing countries) revealed moisture stress mutually of the foremost constraints to wheat production with and estimated annual yield loss of 19 to 50% (Kosina et al., 2007). Drought stress has been recognized jointly of the most important abiotic factors limiting wheat production in India (Joshi et al., 2007), Pakistan (Kisana et al., 2008) and Nepal (Bhatta et al., 2008). In Nepal, drought majorly winter drought constraints on yields have increased in importance as temperature change result in increasingly hotter and drier days (WFP, 2009). As a result, crop growth rate is reduced and yield is lowered. The water availability can cause significant changes in grain components, and consequently in grain quality; the changes differ within the event of excess water or lack of water. Plants that undergo periods of drought suffer decreased photosynthetic activity during this era, consequently affecting the grain formation (Jiang et al., 2009). To get a top quality grain, it is necessary that proteins accumulate within the grain. This process is strongly influenced by water availability, and therefore the nutritional conditions within which the plant grows (Rodrigues and Teixeira, 2010). Dryness causes stress in plant growth which causes yield reduction of 30-50% in drought stress because of low humidity in plant growth which occurs as a result of the high evapotranspiration, temperature, high intensity of sunlight (Ghodsi et al, 1998).During financial year 2005/06 food production in Nepal was stricken by drought with reported decreases within the average wheat production by 3.3%.

1.5 Genotype

Promising wheat genotypes for rainfed condition identified from these researches are NL1094, Bhrikuti, NL 1093, NL1193 and BL 4406

1.6 Drought Tolerance

The capability of plant to maintain their growth and development during water deficit conditions is understood as drought tolerance. (Rijal et al., 2021). It is a sophisticated mechanism and plants modify its different physiological and biochemical factors to fight against the water deficit conditions so as to keep up its normal growth and yield capacity. Different researchers have exploited the genes that are liable for drought stress and are categorized through RNA sequencing and therefore the Affymetrix Gene Chip technology ((Dugas, 2011) . Researchers found that different types of kinase like CDPKs (calcium-dependent protein kinases), CIPK (CBL interacting protein kinase), SnRK2 (sucrose non-fermenting protein-related kinase 2) and MAPKs (mitogen-activated protein kinases) also shows some response to drought stress ((Malone, 2011).. There is a correlation between the drought and antioxidant system and shows positive response towards it. Reports suggested that Reactive Oxygen Species (ROS) like OH (Hydroxide), H_2O_2 (Hydrogen Peroxide), SOD (Super Dioxide) and oxygen which is singlet are created in drought conditions ((Nezhadahmadi, 2013)). A number of the studies shows that wheat genotype having lower malondialdehyde (MDA) content and greater osmotic regulator has helpful for obtaining tolerance against drought (Nezhadahmadi, 2013). All these parameters have important role in drought tolerance and it will be useful for choosing drought tolerant varieties and lines particularly at reproductive stage (Almeselmani, 2012).

2. Conclusion

The effects of drought on the wheat plant are variable, counting on the phenological stage of the plant, additionally the duration, intensity, and frequency of the drought. The crop evapotranspiration increases the duration of the phenological cycle until the stages comprising the start of heading until the top of flowering, which is the most drought-sensitive stage of the crop. At ripening, the evapotranspiration decreases to avoid wasting and allocate the energy to grain yield. Within the initial emergence phase, the drought can severely affect the number of plants per square meter. In the tillering phase, the number of tillers per plant is affected, during stem elongation, plant height is affected. At the flowering stage, processes associated to fertilization and therefore the fixation of grain is affected most severely, leading to a decrease within the number of viable seeds per area. In the grain formation stage, the capacity to translocate the assimilates to the grain is affected, which successively affects the grain weight. By understanding the physiological, morphological, and biochemical responses of wheat under this condition, it helps us to spot drought tolerance mechanism and develop drought tolerant varieties of wheat.

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