REVIEW ARTICLE

EFFECT OF DROUGHT & IRRIGATED ENVIRONMENTAL CONDITION ON YIELD & YIELD ATTRIBUTING CHARACTERISTIC OF BREAD WHEAT-A REVIEW

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ABSTRACT

Wheat is one in all the most necessary cereal crops of the world having multiple uses of its own. However, its production is severely restricted by drought up to 60% reduction in the yield. The production of Reactive Oxygen species (ROS), Degradation of photosynthetic apparatus, thereby reducing the photosynthetic Carbon metabolism, declining net CO₂ assimilation rate (NAR) & ultimately reducing dry matter accumulation is the cause & effect of reduced mean yield under drought condition. Lack of breeding for drought adaptive traits is leading to low productivity of wheat of 2.85t/ha in Nepal. Climate change leading to global warming & Drought is the major threat to most of agricultural crops grown in tropical & subtropical areas including wheat that causes significant losses by altering the physiological, biochemical & morphological traits of wheat genotypes. It is very important for us to adapt our genotypes to drought stress environment for better nutritional & dietary security of mankind. It is very challenging task for researchers to develop such drought tolerant high yielding variety, more research are needed. Scientists have been working for drought adaptive traits to minimize loss caused by drought to maintain high productivity & production to achieve the goal of zero hunger & malnutrition.

KEYWORDS

Drought, Irrigated, Moisture stress, Reactive oxygen species (ROS), Stress.

1. INTRODUCTION

Wheat is the one of the most important cereals crop of family Gramineae (Class Liliopsida) (Shewry, 2009). It is ranked first in the world and third most important cereal crop (after rice and maize) in Nepal in terms of production and area under cultivation both (MOALD, 2017). In National Gross Domestic Product (GDP) of Nepal, Agriculture contributes about 26.50% of the share. Nepal was producing 2,005,665 tons from 703,992 ha of Land on fiscal year 2018/19 (MOALD, 2017). In Nepal, Only 69.2% of total agricultural area of Nepal is irrigated of which, 77.7% lies in Terai or plains and the remaining 22.2% lies on river valleys, upland valleys & terraces of hills & mountains, clearly showing that Nepalese agriculture is still rainfed type. (ADB, 2013; MOALD, 2017). Of the agricultural GDP of Nepal, cereal shares about 37%, among which wheat alone shares 7.14% (Agrifood Consulting International Ministry of Agricultural Development Singhdurbar, n.d.). Most of the wheat production (65.2%) occurred in Terai region which is cultivated under 57.8% of total area of cultivation. In Only 23% of the total land area of Nepal, Improved varieties cover about 95.8% of the total wheat area. Whereas, 66.21% of total wheat crop area is grown under irrigated environment (MOALD, 2017).

Wheat has a great role in nutritional security of Nepal. It occupies 24% of the total cereal area & 20% of the total cereal production of Nepal (MOALD, 2017). Cultivation of high yielding varieties as well as improved irrigation facilities has increased yield of wheat by more than 3 times in

Terai (G. Pandey et al., 2017). The low productivity of wheat in Nepal is because of Low yielding varieties, low use of production inputs like seeds, fertilizers etc. Drought, by definition is a water deficit condition that limits crop production by inducing a dramatic change in morphological, biochemical, physiological & molecular aspect of plant (Sallam et al., 2019). In 2013, about 65 million ha of wheat cultivated land was affected by drought stress condition (FAO, 2013).

Drought, an abiotic stress limits yield severely by impairing various plant at their various growth & development stages more than any other abiotic stresses (Agricultural, 2018). Drought stress affects the functioning of numerous gene each with minor polygenic effect (Bernardo, 2008). Some of the gene located as quantitative trait loci exhibits those additive & non additive gene effects. The polygenic effect of drought tolerance genes with interaction with environment typically has low heritability (*Bulm 2010.Pdf*, n.d.) (Yu et al., 2017) found that drought affects more than 60% wheat production worldwide specially in high income countries to that of 32% in low income & underdeveloped countries (Agricultural, 2018). The low productivity of wheat in Nepal is because of Low yielding varieties, low use of production inputs like seeds, fertilizer etc, lack of irrigation & poor soil fertility management practices (Khadka, 2016). Nepal is rich in biodiversity (Shrestha, Shrestha, & Mission/Nepal, 1999) and hence encompasses the existence of four hundred and five local landraces of wheat from northwestern districts of Jumla and Humla (Pokhrel et al., 2013). Genetic resources provide an invaluable gene pool for crop

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breeding (Reynolds et al., 2007), the majority of wheat landraces in Nepal were uncharacterized for drought tolerance hence characterized for irrigated condition and their potential to improve drought adaptation is not quantified.

There are various factors affecting the yield and yield attributing characters of wheat. There is a positive association between the flag leaf area and the yield in the bread wheat (Khaliq et al. 2008). Correspondingly, specific flag leaf area also exhibited strong positive relationship with yield, while negative association with specific leaf weight. Relative water content was found positively associated with the relative dry weight (Clarke et al., 1991). (Tiwari and Rawat, 1993); (Sharma et al., 1995) and (Yagdi and Sozen, 2009) reported that grain yield per plant in wheat was significantly and positively correlated with plant height, ear length, tillers per plant, biological yield and ears per plant. (Munir et al., 2007) found a positive correlation between biological yield of wheat with grain yield, tillers per plant, test weight & flag leaf area (FLA) whereas a strong negative correlation with days of heading of plant & harvest index (HI).

(Subhani and Chowdhry, 2000) found a positive relationship of grain yield with flag leaf area (FLA), plant height (PH), spike length, grains per spike, test weight (TW), biomass per plant and harvest index, while days to booting was found to show negative correlations with grain yield. These yield determining factors clearly suggest the interrelationship of Effect of moisture on yield of Bread wheat.

2. OBJECTIVES

The objective of the study were to know the relationship between various morpho-physiological traits of Bread wheat in response to different moisture regime environments (i) Drought (Moisture stress) environment (ii) irrigated (Optimum moisture) environment & their co-relationship on yield & yield attributing characteristic of Bread Wheat (*Triticum aestivum* L.).

3. METHODOLOGY

This review article is based on various secondary information's gained from various research & review article authorized by known journals across the globe but preferences were given to the research conducted in recent years in similar agro meteorological conditions to that of Nepal.

4. RESULT & DISCUSSION

Water is the most important factor contributing in the growth, development and the overall yield of the crops. There are various studies showing the relation between the moisture content in the soil and the various physiological aspects and phenological stages of the plants. Water requirement of wheat is estimated to be 266.8-500mm which is higher as compare to other crop (Poudel et al., 2020). However, the severity & duration of drought stress determines the extent of the yield loss by shortening the life cycle & duration of the grain filling in bread wheat.

According to (Leilah & Al-Khateeb, 2005), the panicle no, grain weight and biological yield influenced the grain yield in a wheat cultivar the most. Similarly, the plant height, biomass and yield are more sensitive traits to the water deficit condition in comparison to the number of spikes and 1000 grain weight. A number of tillers per plant, kernels per plant, 1000 grain weight, awn length, and peduncle length affect wheat tolerance to drought (Nouri-Ganbalani et al. 2009; Aminzadeh 2010). Drought affects all plant development stages from germination, vegetative and reproductive growth to grain filling and maturation of the crop (Hossain et al. 2012) Drought reduces nitrogen (N) uptake efficiency and utilization by plants.

Due to the impaired membrane permeability, the transpiration rate and the active transportation of minerals both are reduced causing repressed root absorbing power and finally resulting in deprived nutrient uptake. Arid and semi arid zones of world are severely affected by water stress and drought is being the leading causes of limited agriculture production. Water stress is shown affecting various growth variable and functions. Due to the stomatal closure, the intake of CO₂ is reduced and a high level of oxygen inside results in production of reactive oxygen species, caused by the partial reduction of oxygen and causing the rupture of membranes, making leaky therefore affecting processes like respiration

photosynthesis and overall growth and development of the plant. Reactive oxygen species have shown to seriously damage the production of cellular components such as carbohydrates, nucleic acids lipids and proteins, (reddy) (Waraich et al. 2011; Reddy et al. 2014). The effect of the drought stress on the various phenological stages of wheats can be shown with the help of data below.

4.1 Days to Heading

The mean number of days to heading for irrigated & drought conditions was 78.22 & 76.587 days respectively. The significant reduction in Days to heading under Drought condition is due to the matching of growth duration of plants to soil moisture availability. (Araus et al., 2010) states that drought escape occurs when phenological development is successfully matched with the period of soil moisture availability & where crop growth season is shorter & terminal drought stress occurs. The reduction in the days of heading is due to the exposure of leaf to heat that cause significant reduction in the activity of photosynthetic enzyme RuBisCO (Ribulose 1,5 Bisphosphate Carboxylase oxygenase) which results in low amount of CO₂ fixation (Mafakheri et al., 2010)

4.2 Days to maturity

The mean number of days to maturity for irrigated & drought condition was 115.3 & 110.41 days respectively. Decrease in Maturity days under drought is controlled by the lower intake of nutrients in the plants which decreased chlorophyll content in leaves due to the lack of N needed for the assimilation. Early senescence from drought is due to the loss of chloroplast integrity in leaf and also causing early maturity (Poudel et al., 2020).

4.3 Plant Height

Plant height for irrigated & drought stress condition were obtained 89.53 & 68.21 cm respectively. The significant decrease in plant height is due to the substantial decrease in wheat biomass during tillering and booting stage, as most of the energy produced is utilized for root development in search of moisture from soil. Reactive Oxygen species causes the alternation in the redox potential of cell membranes, thereby triggering cell death and cause in the reduction of plant growth and productivity eventually (Hasanuzzaman et al., 2018).

4.4 No. of grain /spike

No. of grain /spike for irrigated & drought condition was 43.32 & 36.68 respectively (Poudel et al., 2020). Drought stress condition causes the reduction of absorptions of micronutrients (Noman et al., 2018). Lack of water in the absence of nitrogen to the plants affects the leaf water relations, chlorophyll fluorescence, reduction in the grain filling which ultimately reduce the number of grains per spike (Mobasser et al., 2014)

4.5 Mean 1000 kernel wt.

The mean 1000 kernel wt. for irrigated & drought condition was: 45.06 & 40.25 (Poudel et al., 2020). As a response to drought stress, plants close the stomata suddenly and result in reduced CO₂ fixation and reduces photosynthates and hence decreases the grain weight consequently (Mafakheri et al., 2010; Yu et al., 2017).

4.6 Mean grain yield

The mean grain yield for irrigated & drought conditions were 3.3 & 1.4 ton/ha respectively. Water is elixir of life that on drought condition limits grain yield by affecting of anthesis & grain filling period. Anthesis and grain filling period of wheat is greatly affected by the water stress. It decreases the water potential, consequently lowering the turgor and stomatal conductance and finally photosynthesis there after lessening the growth and yield of the crop. (Chen et al. 2012).

4.7 Leaf Area Index

The prevention of grain yield leaching on drought condition is accomplished by increase in excised leaf water retention (ELWR), which reflect water retention mechanism in the leaf under stress that may be ascribed to leaf rolling or decrease in exposed leaf surface area & hence increase in the ELWR could be a superior indirect selection criteria for drought tolerance leading to higher grain yield (Sallam et al., 2019). Under

drought condition decreasing pattern in morphological traits can be seen in plant parts above ground level including the leaf area index (kalic and yagbasanlar)

4.8 Mean Yield

Yield is determined by multiple factors, the most important one is chlorophyll content, grain filling period & the number of grain/spike (KILIÇ & YAĞBASANLAR, 2014). Drought has found to cause reduction in the mean yield by 27.5 %. The large yield loss in wheat was caused by a combination of decreases in Grain Weight (-10.6%), GNPP (-15.8%), PNPU (-11.2%) & PL (-14.9%) (Zhang et al., n.d.). (Zhang et al., n.d.) found drought to reduce the mean yield by (27.5%) due to subsistent decrease in grain weight (GW) by (10.6%), Grain Number per panicle (GNPP) by (15.8%), Plant number per unit area (PNPU) by (11.2%) & Panicle length (PL) by (14.9%). Drought was also found to decrease the wheat biomass the most by 34.4% at the tillering stage. It also Results in the decreased CO₂ availability for photosynthetic Carbon metabolism and prohibits plants ability for dry matter accumulation (Chaves et al., 2003). The decrease in photosynthetic activity is due to imbalance in light capture & its utilization, decrease in RuBisCO activity, loss of chloroplast membrane (Kingston-Smith & Foyer, 2000), degradation of chloroplast structure & photosynthetic apparatus, chlorophyll photo-oxidation, destruction of chlorophyll substrate, inhibition of chlorophyll biosynthesis & increase chlorophyllase activity (Kabiri et al., 2014). Yield is determined by rate of photosynthetic activity on plant leaf which is found to be reduced during drought stress condition (Kabiri et al., 2014).

Drought causes reduction in photochemical efficiency of photo system II (PS II) causing reduced CO₂ diffusion brought by reduced turgidity of stomata, reduction in the activity of photosynthetic enzymes & reduction in the biochemical reaction related to Triose phosphate (ATP) synthesis (V. Pandey & Shukla, 2015). Drought also causes significant reduction on RuBisCO activity, loss of chlorophyll integrity, degradation of photosynthetic apparatus & chloroplast structure, destruction of photosynthetic substrate, inhibition of chlorophyll photo-oxidation on C₃ Wheat because of closed stomata & light reaction running inside (Kabiri et al., 2014).

Drought also limits the synthesis of photosynthetic pigment, hence the metabolic distortion brought by drought are more complex than stomatal limitation (Rama Reddy et al., 2014). The closed stomata reduces photosynthesis by reducing stomatal & mesophyll CO₂ conductance (Centritto et al., 2009) resulting in decreased availability of CO₂ for photosynthetic carbon reduction cycle (C₃), declining net CO₂ assimilation rate (NAR) & reducing dry matter accumulation (Chaves et al., 2003). Plant tries to prevent yield loss by closing stomata to reduce transpiration & to conserve water status on plant (Sallam et al., 2019). (Alaei, 2011) found that genotypes higher in chlorophyll content have less effect of drought on yield & found to produce relatively better seed yield under water-deficit condition.

The cultivars that can sustain photosynthetic apparatus & photochemical efficiency under water deficit condition can sustain yield, as a tolerant cultivar enhances total chlorophyll at pre & post anthesis period of wheat growth stage resulting in more stable photosynthetic rate whereas susceptible cultivars reduces both traits at both stage of growth (Dawood et al., 2019). Plants itself tries to adapt to the water stress situation by developing epicuticular wax coating on leaves, leaf rolling & inducing water rolling mechanism (Tahara et al., 1990; Teulat et al., 1997; Balota, 2008). A strong positive correlation has been found on water use efficiency & agronomic parameters of growth & development like Photosynthetic rate, Relative water content (RWC) & stomatal conductance whereas a negative correlation with Transpiration under drought (Akrami & Yousefi, n.d.). Drought also causes low mobility of macro (specially N, P, K) (Noman et al., 2018) & micro nutrients (Mn, Fe & Mo) (Hu & Schmidhalter, 2005) leading to nutrient deficiency specially the active transport & membrane permeability of cations (K⁺, Ca²⁺, & Mg²⁺) (Hu & Schmidhalter, 2005) leading to chlorosis, low chlorophyll development & reducing grain yield (Sallam et al., 2019). Formation of Reactive oxygen species (ROS) like singlet oxygen (¹O₂), superoxide radicals (O₂⁻), hydrogen peroxide (H₂O₂) & (-OH) radical on plant tissue during drought stress condition has also found to cause oxidation of photosynthetic pigments, membrane lipids, proteins & nucleic acids by altering cellular redox potential leading to reduced growth & productivity & ultimately death of

cell (Hasanuzzaman et al., 2018).

5. CONCLUSION

From the study it has been established that the drought stress condition are major problems in wheat production all around the world including Nepal that significantly effects on yield & Yield attributes of Wheat. Drought Stress condition affects in various reproductive & phenological phases like Days of Booting, Days to Heading, Flowering, anthesis Grain filling, 1000 Kernel weight, Test weight & maturity & overall yield by alternation in Various physiological & metabolic stages & also gene expression. However, drought is not only one yield limiting factor but a prominent & significant factor in context of Nepal where Irrigation through irrigating canal is not a feasible option.

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