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INVESTIGATING THE DROUGHT MITIGATING EFFECT OF FARMYARD MANURE IN WHEAT

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Abstract

Wheat is the staple cereal crop of Pakistan. Water deficit is among the leading threats to sustainable crop production under the demanding situations of increased food supply at a rapid rate to meet basic survival requirements. Furthermore, soil amendments that synergistically impact soil and crop must be applied under this `challenging scenario. Farmyard Manure is considered an important source capable of holding water for longer periods, even in soils with poor texture and structure. To assess the impact of FYM on Wheat crop under drought conditions, an experiment was performed in the wirehouse of the Agronomy Department, IUB. CRD with 4 treatments of FYM, $T_{0=}$ Control (N0 FYM), T_1= FYM @ 15 t/ha, T2 = FYM @ 20t/ha, $T_{3=}$ FYM @ 25t/ha and 4 drought levels D_0=Control (Normal Irrigation), D_1= Drought at Tillering, D_2= Drought at Flowering and D_3= Drought at grain Filling was used. Analysis of growth, yield, physiological and biochemical attributes was carried out by following standard protocols. Experimental data under statistical analysis showed that each treatment of Farmyard Manure and drought had a significantly fluctuating impact on wheat crop. However, among FYM treatments, $T_{2=}$ FYM @ 20 t/ha showed a 28% increase in POD, 15% in SOD, 60% in CAT, 18% in APX, 7% in Plant height and 7% lift in 1000-grain weight as compared to other FYM treatments whereas, among drought treatments, D_0=Control (Normal Irrigation) stands best as compare to H_2O scarcity at critical growth and development stages, statistically analyzed data revealed that D_0=Control (Normal Irrigation)showed 11% increase in Plant height, 13% in the number of grains per spike, 5% in Osmotic potential, 3% in Stomatal conductance activities of wheat crop. D3= Drought at grain Filling and $T_{0=}$ Control (NO FYM) were identified as treatment levels with statistically lowest results, respectively.

Keywords: Farmyard Manure, Drought, Wheat, Critical Stages, Yield

INTRODUCTION

The world population is predicted to reach 9.2 billion in 2050; therefore, world food production must be increased by 70% to fulfil global needs. Moreover, global crop production is severely reduced by factors, including biotic and abiotic stresses; these factors report a 30-60% decrease in crop yield (Tester and langridge, 2010). About 35% of the world's population (including more than 40 countries) consumes wheat as a staple food (Razaet al., 2017). Wheat grain is a rich source of energy containing protein (9.4-14 g/100g), Fiber (1.8-2.3 g/100g), fat (1.2-2.5g) and high concentration of carbohydrates (69.1-75.4 g/100g) in addition to this, our daily routine diet products such as bread, cookies and Pastas are also made up of wheat whereas wheat straw is the main component of feed used for livestock (Ken, 2004).

The total cultivated area under wheat crop is 250 mha (million hectares) with 760.1 million tonnes annual production. Among leading wheat-producing countries worldwide, Pakistan is ranked $4^{th,}$ whereas China is ranked at top. In addition to staple food, the wheat crop is essential for food security in Pakistan. The sole wheat crop adds 7.8% annually and contributes 1.8% to the country GDP. Several factors, including environmental factors, reduce the growth and development of wheat, and a limited water supply is a major factor resulting in lower yield (Sinclair, 2005). Water scarcity decreases crop growth and yield (Razaet al., 2012a). Crop growth, development and yield are highly affected due to drought during critical stages. Duration and timing of drought occurrence also play a vital role. Limited availability of water is major stress from environmental factors resulting in yield losses (Baquedanoet al., 2007 & Khan et al., 2010; Mehboob et al., 2020ab)

Drought is a phenomenon in which the unavailability of water for extended periods negatively impacts crop growth and yield. Yang et al. (2004) defined drought as a condition with less rainfall negatively affecting nature. Worldwide, crop growth and production are adversely affected due to drought (Yang et al., 2004; Javed et al., 2022; Rasheed and Malik, 2022). Lack of moisture or unavailability of water during critical stages of wheat crop resulted in early growth, development and maturity, resulting in low values of protein contents in grain by alternating growth processes (Bonfilet al., 2004). Drought emerged as a serious threat to wheat crop in both arid and semi-arid areas, as 50 %water supply can lower wheat grain yield by 41% (Ramezanpoor and Dastfal, 2004). Drought stress alters crop plants' physiological and metabolic processes by damaging plant growth (Beck et al., 2007). Seeds require an adequate amount of moisture for germination. Plant processes at cellular and internal levels are adversely affected by water shortage. Under drought conditions change in nutrient levels resulted in change in wheat grain protein content (Bonfil, 2004). Many scientists have reported that decrease in wheat grain yield occurred due to the unavailability of water, 22% decrease in grain

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yield under 25% water application was reported by Kumar et al., (2005). According to a study carried out by Dencicet al., (2000), water scarcity during the vegetative growth stage harmed r crop growth Low soil moisture in the presence of limited water resulted in minimum leaf area, lack of pollination, less anther formation and a limited amount of nutrients essential for growth and development (Pettigrew, 2004). Enzymatic activity was also altered due to changes in physiological conditions under prevailing drought stress. In addition, transpiration, stomatal conductance, and processes of photosynthesis were also disturbed (Razaet al., 2012a). Ozturket al., (2022) found that water shortage also influences the anthesis stage in wheat crop. Farmyard Manure is usually defined as manure made up of organic matter containing solid animal waste, which is used to improve soil quality, and health and increase crop yield. Since thousands of years, Farmyard Manure has been used as the major material for maintaining and improving soil health. Among organic materials entering soil Farmyard Manure (FYM) is described as best. FYM is also described as a heterogeneous mixture of well-decomposed organic material, including urine and dung of farm animals, and leftover fodder feed served to animals. Farmyard Manure is an important and essential source of required organic matter for crop production in livestock farming systems (Satyanarayanaet al., 2002).

Therefore, Farmyard Manure can be used as a substitute for highly expensive and dangerous inorganic fertilizers. As compared to inorganic fertilizers, organic manures are eco-friendly. FYM application significantly improves soil physical, and chemical health and enhances movement of soil water & air (Satyanarayanaet al., 2002). An increase in crop growth, development and yield was recorded due to these improved soil characteristics (Satyanarayanaet al., 2002). Organic manure improves water movement and aeration in soil and increases water holding capacity of soil by influencing physical, chemical and microbial activities and also includes the micronutrients such as Cu, Mn, Fe, Zn, P, K and nitrogen, so there will be less need of macro and micronutrients due to application of organic manures (Prof. Rajinderet al., 2007). According to Nyle and Brady (2003), the formation of clay humic complexes by organic manure also improves soil ability to adsorb essential micro, and macronutrients and the activity of micro-organisms carrying our mineralization process is also accelerated. Organic fertilizers also determine the availability of native nutrient, whereas organic matter also acts as a medium of energy for microbial activities and plant nutrition. The application of organic manure helps microorganisms improve soil structure through polysaccharides production (Guar, 1990).

Soil water holding ability permeability is enhanced by adding Farmyard Manure (Hussain& Khan, 2000; Hussainet al., 2004). Different types of organic manure, such as (Farmyard Manure, green manure, organic amendment and municipal solid waste) have been used to increase soil fertility and nutrients level (Dao and Cavigelli 2003). In general, biological, chemical and physical characteristics were improved by incorporating manure and soil (Hussainet al., 2004). Improvement in soil structure and texture was reported due to a decrease in bulk density and others due to animal manure addition (Hatiet al., 2007; Fares et al., 2008). Sarwar (2005) also found that wheat grain yield and yield components significantly increased with the application of different organic materials, resulting in the compost being the most superior. Yassenet al. (2006) found that irrigation at 60% water

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holding capacity and applying mineral nitrogen 60 kg/fed, with the presence of poultry manure as an organic fertilizer.

MATERIAL AND METHODS

A study entitled "Cooperative effect of Farmyard Manure in vindicating the drought on wheat under Arid conditions" consisting of wire house experiment was carried out at a research farm of the Agronomy Department in the Faculty of Agriculture and Environment, The Islamia University of Bahawalpur. Wirehouse experiments were carried out under CRD (Completely randomized design). In three replications, selected varieties from the screening tests were used to determine the effects of different Farmyard doses on wheat under drought at different stages of growth.

Factor 1: **Dose levels of Farmyard Manure**

Following dose levels of Farmyard Manure were used in the wirehouse

T_0 = Control (No FYM)

T_1= FYM @ 15t/ha

T_2= FYM @ 20t/ha

T_3= FYM @ 25t/ha

Factor 2: Drought at different crop growth stages

D_0 =Control (Normal Irrigation)

D_1 = Drought at Tillering

D_2 = Drought at Flowering

D_3 = Drought at Grain filling

Soil physiochemical analysis report as tested in RARI Lab

Characteristics		**Depth**	
		0-15cm	**15-30cm**
OM		0.77%	0.55%
pH		8.42	8.60
EC		252 µS/cm	231 µS/cm
T.S.S.		0.8%	0.1%
Available-P		7.11ppm	5.11ppm
Available-K		115ppm	112ppm
Saturation %		37%	34%
Soil separates	Sand	38%	36%
	Silt	41%	38%
	Clay	21%	26%
Textural		Loam	Loam

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Plant height at maturity (cm)

Height of matured plants was recorded from top to bottom by using measuring tape. 10 plants were selected randomly, and the average plant height was calculated.

Spike length (cm)

The spike length was measured using a scale at the time of crop maturity. Fivespikes were chosen from each experimental pot. After measuring randomly selected spikes from top to bottom, the data average was calculated.

1000-grain weight (g)

Manual counting of 1000 grains from selected spikes was performed from each experimental unit. An electric weighing balance was used for calculating the 1000-grain weight.

Biological yield (g pot^{-1})

Biological yield was recorded by harvesting selected plants at maturity. A hand-held weighing balance was used for weighing the Biological yield of each experimental pot. Recorded data was converted in g pot^{-1} and then averaged.

Grain yield (g pot^{-1})

The grain yield of each treatment was recorded at the time of harvest. After manual threshing, grains were weighed using a digital weighing balance. Recorded data was changed into g pot$^{-1,}$ and the average grain yield was later recorded.

Physiological Observation

Leaf relative water contents (%)

Random selection of 10 plants with the fully expanded youngest leaf (the third leaf from top) was done from each treatment under observation. It was selected to define the leaf's relative water contents (RWC). Soon after removing from lamina base, freshly harvested leaves were packed inair-tight plastic bags and transferred to the laboratory. Harvested leaves were weighed to record their fresh weight within 2 hours after removal from the plant body. Afterwards, leaves were soaked in distilled water for 16-18 hours at room temperature then soaked leaves were taken out to determine TW (turgid weight), careful drying of bottle-soaked leaves with the help of tissue paper was done to get the exact turgid weight. Oven drying of leaves at 70°C for 3 days (72 hours) was practised to get the weight of dried leaves. The formula given by Lazcano-Ferrat and Lovatt (1999) was used for calculating Relative water content (RWC).

$$RWC\ (\%) = (FW - DW)/\ (TW - DW) \times 100$$

Where,

FW= Fresh weight
DW= Dry weight
TW= Turgid weight

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Leaf water potential (MPa)

After removing the selected fully expanded 4th leaf from the top leaf, water potential (MPa) was recorded immediately in the field with the help of a water potential measuring apparatus (Chas W. Cook Div., England).

Leaf osmotic potential (MPa) or (ψ_s)

To determine leaf osmotic potential (MPa), water potential was defined by freezing a certain portion of the leaf for 2 weeks. After that leaf was softened and crushed with the help of a metal rod aiming extraction of frozen sap. Sap was passed from the process of 4 minutes of centrifugation (8000rpm × *g*), and later on, it was used in Vapor Pressure Osmometer (Wescor 5520, Logan, USA) for obtaining osmotic potential.

Leaf turgor pressure (MPa)(ψ_p)

Leaf turgor pressure (MPa) will be calculated as

Turgor Potential = Water Potential –Osmotic Potential

Where,

Turgor Potential= Leaf turgor pressure (ψ_p)

Osmotic Potential = leaf osmotic potential (ψ_s) and

Water Potential = leaf water potential (ψ_w)

MPa= Mega pascals

Leaf stomatal conductance (mmol of H_2O $m^{-2}s^{-1}$)

Automatic porometer MK-3 (Delta-T Devices, Burwell Cambridge, England) Hertford, Herts, England) was used for determining stomatal conductance (stomata resistance).

Biochemical Analysis

Analysis of 4 enzymes APX, CAT, POD and SOD was performed by following standard instructions

APX (Ascorbate per oxide)

Method purposed by Nakano and Asada (1981) was used for measuring the activity of Ascorbate peroxides (APX) which consists of taking 1 gram of leaf sample in a reaction mixture of 3ml made up of 50mM of potassium phosphate (pH 7.0), 2mM of ascorbic acid (AsA) and 2mM H_2O_2. A decrease in absorbance at 300nm (extinction coefficient 0.74$mM^{-1}cm^{-1}$) was used to determine AsA oxidation. 1 unit of APX (ascorbate per oxide) was defined as the amount of enzyme oxidizing one micromole of AsA per minute

CAT (Catalase)

The procedure followed by Vanackeret al. (2000) was adopted to measure Catalase (CAT) activity. 0.15g of freshly harvested leaves were dipped in liquid nitrogen and crushed into a powder in a solution of 1-mL containing 0.1M KH_2PO_4/KOH buffer, pH 7.4,

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and 30mM dithiothreitol. Samples were centrifuged for three (3) minutes at 13,000 rpm & were kept in ice until further examination. Polaro graphical examination of Catalase was performed at 20°C in a liquid phase oxygen electrode (Hansatech, King's Lynn, UK)..

Peroxidase (POD)

POD activity was analyzed in 2 fractions**.** Standard procedures and protocols adopted by others were used to examine POD (peroxides) activity.

Superoxide dismutase (SOD)

The procedure adopted by Beyer and Fridovich (1987) was followed to examine SOD (Superoxide dismutase) activity. For SOD analysis, completely expanded leaves under shoot apex were collected, kept in liquid Nitrogen and stored. Buffer mixture of 1ml of 50M potassium phosphate and 1mM of EDTA (pH 7.5) was used for homogenizing leaf samples. Cheesecloth was used for filtering homogenates which were centrifuged for 15 minutesat 4°C. 1 unit of enzyme activity was determined as the enzyme quantity consumed to cause 50% inhibition of nitro blue tetrazolium. Spectrophotometer was used to measure reduction at 560 nm. Unit per gram of protein is used to express SOD activity.

Statistical analysis

Data were analyzed statistically using Fisher’s Analysis of variance technique, and significant treatments’ means were compared using the LSD test at a probability level of 5% (Steel et al., 1997).

RESULTS

1. Plant Height (cm)

Statistically analyzed data of plant height in Table#1 shows that wheat plant height was significantly affected by different drought treatments at critical growth stages and changes with Farmyard Manure treatment. Wheat maximum plant height was reported under the Control treatment (62.32) where FYM was applied @ 20 t/ha, and the lowest value was present in Drought at grain filling where no FYM was applied, value was 54.59. Interaction relation was statistically non-significant between drought and Farmyard Manure. No drought and FYM application @ 20t/ha produced promising results dueto the absence of drought and proper application of FYM.

2. Spike Length (cm)

Analytically arranged data on Spike length is shown in Table#1, indicating that different drought treatments at critical growth stages and Farmyard Manure treatments significantly impacted wheat spike length. In wheat plants, spikes with the highest spike length were present in D_0= Control (Normal Irrigation) treatment that was (13.29) where FYM was applied @ 20t/ha, and a statistically minimum length of the wheat spike was in Drought at grain filling (11.04) with no FYM application. Interaction relation was statistically non-significant between drought and Farmyard Manure.

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3. 1000-Grain Weight (g)

Statistically analyzed data regarding 1000-grain weight represented by Table# 1shows that different levels of drought at crucial growth and development stages and Farmyard Manure treatments significantly impacted weight of 1000-grains. Statistically, the maximum 1000-grain weight of Wheat plants was recorded in **D_0**=control (Normal Irrigation). It showed a 31.83 value with FYM application @ 20 t/ha, and the lowest 1000-grain weight was present in Drought at grain filling stage 26.27 with no FYM application. Interaction relation was statistically non-significant between drought and Farmyard Manure.

4. Grain Yield (g pot^{-1})

Statistically analyzed data regarding grain yield per pot, represented by Table# 1shows that different levels of drought at crucial growth and development stages and Farmyard Manure treatments significantly impacted grain yield. Statistically, maximum grain yield of Wheat plants was recorded in D_0= Control (Normal Irrigation) treatment (10.16) with FYM application @ 20t/ha and lowest in Drought at grain filling (7.94) in the absence of FYM. Interaction relation was statistically significant between drought and Farmyard Manure. FYM application might have boosted the photosynthesis, resulting in more synthates production and ultimately more grain yield.

5. Biological Yield (g pot^{-1})

Statistically analyzed data regarding biological yield per pot represented by table# 1 shows that grain yield has significantly fluctuated with different levels of drought at important growth and development stages and Farmyard Manure treatments. The statistically maximum biological yield of Wheat plants was recorded in D_0= (Normal Irrigation) treatment (16.21) with FYM application @ 20 t/ha and lowest in Drought at grain filling (10.79) where FYM was applied @ 15 t/ha. Statistically non-significant interaction activity was observed between drought and Farmyard Manure. 20 t/ha application of FYM might have boosted the growth of plants but drought at grain filling stage had adverse effects on crop

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Table 1: Yield parameters of wheat crop as affected by different FYM application and different drought levels

Treatment	Plant Height (cm)	Spike Length (cm)	1000-grain weight (g)	Grain yield (g pot^{-1})	Biological yield (g pot^{-1})
T_0D_0	57.22	12.61	28.64	8.82	13.28
T_1D_0	58.59	12.68	29.12	9.56	13.98
T_2D_0	62.32	13.29	31.83	10.16	16.21
T_3D_0	60.71	12.95	29.91	9.97	14.97
T_0D_1	56.31	11.86	27.81	8.78	12.56
T_1D_1	58.11	12.39	27.92	8.51	13.39
T_2D_1	60.20	12.84	29.84	9.90	14.64
T_3D_1	59.17	12.64	29.04	9.82	13.83
T_0D_2	55.25	11.50	27.82	8.44	12.20
T_1D_2	57.08	11.80	27.45	8.23	12.24
T_2D_2	59.44	12.35	29.17	9.50	13.59
T_3D_2	57.60	12.21	29.02	9.40	12.56
T_0D_3	54.59	11.04	26.27	7.94	11.70
T_1D_3	55.96	11.16	26.58	8.05	10.79
T_2D_3	57.16	12.03	27.64	8.59	11.75
T_3D_3	56.53	11.78	27.52	8.35	12.01

T_0= Control (No FYM) D_0= (Normal Irrigation)

T_1= FYM @ 15 t/ha D_1= (Drought at Tillering)

T_2= FYM @ 20 t/ha D_2= (Drought at Flowering)

T_3= FYM @ 25 t/ha D_3 = (Drought at Grain Filling)

6. Water Use Efficiency (g $pot^{-1}mm^{-1}$)

Statistically analyzed data regarding Water Use Efficiency (WUE) represented by table# 2 shows that WUE (water use efficiency) fluctuated significantly with different levels of drought at important wheat crop stages and Farmyard Manure treatments. Statistically, the maximum WUE of Wheat plants was recorded in D_0= (Normal Irrigation) treatment (60.53) where FYM was applied @ 20 t/ha and lowest in Drought at grain filling (52.80) with no FYM application. Statistically, non-significant interaction activity was observed between drought and Farmyard Manure. FYM application @ 20 t/ha and normal irrigation might have urged the plant to use water efficiently for working properly. Ample water supply is necessary to avoid heat stress and maximum photosynthesis activity, resulting in more synthetic production and, ultimately, the desired crop yield.

7. Leaf Relative Water Content (%)

Table# 2 represents the relative water contents of wheat leaf. The prevalence of drought stress at different sensitive stages during crop life cycle and different treatment levels of Farmyard Manure had a significant impact on leaf-relative water contents. Statistical analysis revealed that maximum mean readings of LRWC were found in **D_0**= (Normal Irrigation) treatment (83.30) with T_2=FYM application @ 20 t/ha and relative water

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contents of wheat crop leaf were lowest in D_3= drought at grain filling (73.26) with T_0= no FYM application. Statistically, non-significant interaction activity was observed between drought and Farmyard Manure treatments.

8. Osmotic Potential (MPa)

Table# 2 represents the potential osmotic contents of wheat leaf. The emergence of drought stress at different critical intervals during wheat crop life cycle and different Farmyard Manure treatment levels significantly impacted wheat crop's Osmotic potential. Statistical analysis revealed that maximum values of Osmotic Potential were found in **D_0**= Control (Normal Irrigation) treatment (1.16) with **T_2**= FYM application @ 20 t/ha and osmotic potential of wheat crop leaf was reported lowest by **D_3**= drought at grain filling (1.05) wit**T_0**= no FYM application. Statistically, non-significant interaction activity was observed between drought and Farmyard Manure treatments.

9. Turgor Potential (MPa)

Turgor Potential contents of wheat leaf are represented by Table# 2. The emergence of drought stress at different critical intervals during the wheat crop life cycle and different treatment levels of Farmyard Manure significantly impacted the Turgor potential of wheat crop. Statistical analysis revealed that maximum values of Turgor Potential were found in control treatment (0.26) along **T_2**= FYM application @ 20 t/ha and wheat crop leaf turgor potential was reported lowest by **D_3**= drought at grain filling (0.19) along with no FYM application. Statistically, non-significant interaction activity was observed between drought and Farmyard Manure treatments. Leaves of plants lost the leaf turgor pressure in the presence of drought stress however, in the presence of water i.e. in controlled conditions, the value of turgor pressure was maximum. While on the other hand, the presence of FYM ensured the availability of water for a prolonged period hence, promising value of leaf turgor pressure were obtained.

10. Stomatal Conductance (mmol m^{-2} s^{-1})

Table# 2 represents the stomatal conductance activity of wheat leaf. Emergence of drought stress at different critical intervals during wheat crop life cycle and different treatment levels of Farmyard Manure had a significant impact on the Stomatal Conductance activity of wheat crop. Statistical analysis revealed that maximum values of Stomatal Conductance were found in D_0= Control (Normal Irrigation) which was 431.48 with T_2= FYM application @ 20 t/ha and activity of wheat crop leaf Stomatal Conductance was reported lowest by D_3= drought at grain filling (408.73) with no FYM application. Statistically, non-significant interaction activity was observed between both treatments.

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Table 2: Growth parameters of wheat crop as affected by different FYM application and different drought levels

Treatment	Water Use Efficiency (g $pot^{-1}mm^{-1}$)	Leaf Relative Water Content (%)	Osmotic Potential (MPa)	Turgor Potential (MPa)	Stomatal Conductance (mmol m^{-2} s^{-1})
T_0D_0	55.43	76.94	1.11	0.22	423.46
T_1D_0	56.80	77.89	1.12	0.24	427.15
T_2D_0	60.53	83.30	1.16	0.26	431.48
T_3D_0	58.92	81.14	1.14	0.23	423.99
T_0D_1	54.52	76.56	1.08	0.20	414.73
T_1D_1	56.32	76.70	1.11	0.21	415.18
T_2D_1	58.41	80.66	1.14	0.24	423.18
T_3D_1	57.38	80.49	1.12	0.23	421.73
T_0D_2	53.46	75.85	1.07	0.20	414.94
T_1D_2	55.29	76.21	1.10	0.21	416.93
T_2D_2	57.65	79.61	1.12	0.22	421.79
T_3D_2	55.81	79.38	1.09	0.21	419.84
T_0D_3	52.80	73.26	1.05	0.19	408.73
T_1D_3	54.51	75.34	1.08	0.19	414.33
T_2D_3	55.37	78.20	1.10	0.21	417.06
T_3D_3	55.27	77.74	1.08	0.20	417.63

T_0= Control (No FYM) D_0= (Normal Irrigation)

T_1= FYM @ 15 t/ha D_1= (Drought at Tillering)

T_2= FYM @ 20 t/ha D_2= (Drought at Flowering)

T_3= FYM @ 25 t/ha D_3 = (Drought at Grain Filling)

11. APX (Ascorbate Peroxidase)

APX (Ascorbate peroxidase) activity data is represented by Fig#1, which shows that drought application at different critical stages and Farmyard Manure treatments had a statistically significant effect on APX (Ascorbate) activity of wheat crop. Mean APX (Ascorbate peroxidase) activity was higher (1.49) in plots made up of control treatment; however, minimum mean activity of Ascorbate peroxidase was recorded in plots receiving Drought at Grain Filling (1.08). Farmyard Manure treatments showed maximum activity of Ascorbate peroxidase (APX) in T_2= FYM @ 20 t/ha (1.43), which was followed closely by T_3= FYM @ 25 t/ha F_3 (1.21) and statistically APX activity in T_0= control (No FYM Use) which was 1.17 statistically significant interaction activity was observed between drought and Farmyard Manure treatments.

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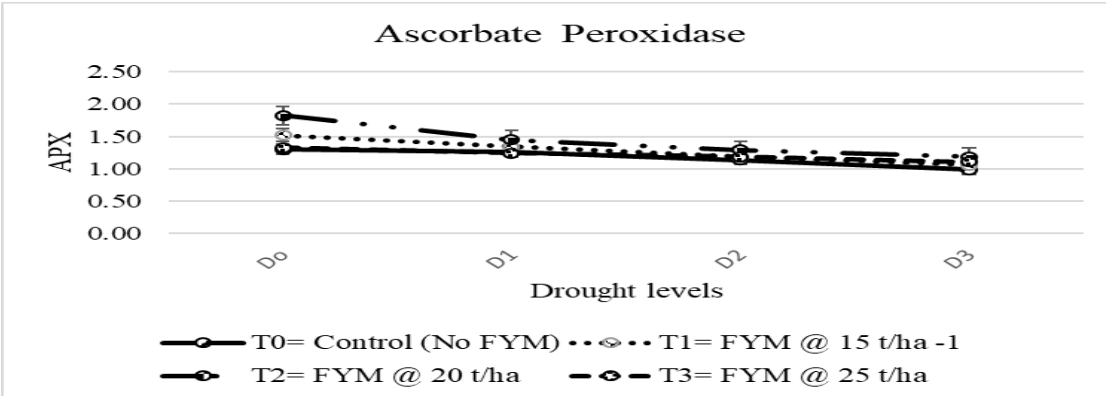

Fig 1: Effect of FYM treatments on Wheat plant APX under Drought stress

LSD for Drought = 0.01 **LSD for FYM** = 0.01 **LSD for Drought * FYM** = 0.00

12. CAT (Catalase activity)

CAT (Catalase) activity data is represented by Fig#2 which shows that drought application at different critical stages and different FYM treatments had a statistically significant effect on the CAT (Catalase) wheat crop activity. Mean CAT activity was higher (3.43) in plots of control treatment; however, the minimum activity of Catalase was recorded in plots receiving Drought at Grain Filling (2.80). Farmyard Manure treatments showed maximum mean CAT (catalase) activity in T_2= FYM @ 20 t/ha, which was 2.71, followed closely by FYM @ 25t/ha which was 1.45, and statistically, Catalase activity in T_0=Control (No FYM) was 1.80. Statistically, non-significant interaction activity was observed between drought and Farmyard Manure treatments.

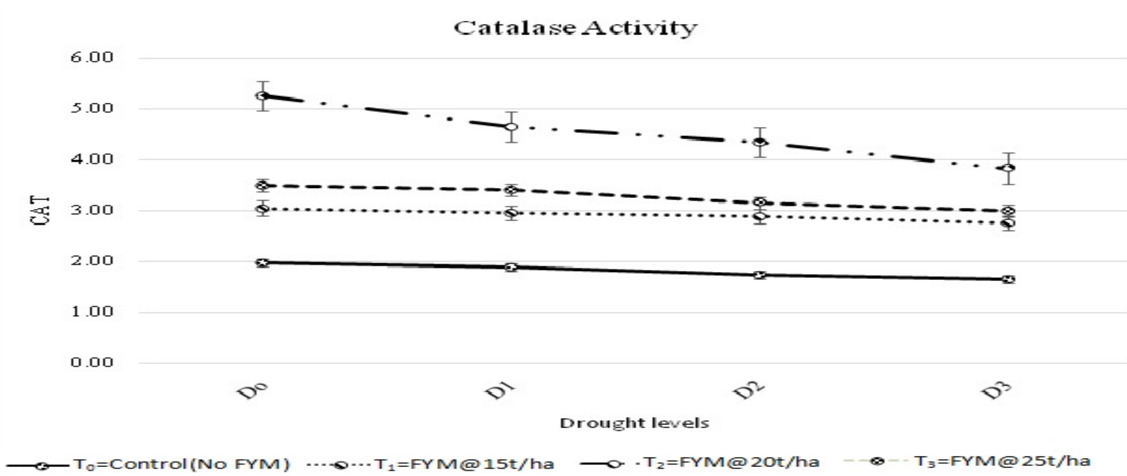

Fig 2: Effect of FYM treatments on Wheat plant CAT under Drought stress

LSD for Drought = 0.20 **LSD for FYM** = 0.20 **LSD for Drought * FYM** = 0.033

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13. POD (Peroxidase Activity)

POD peroxidase activity data is represented by Fig#3 which shows that drought application at different critical stages and different Farrmyard manure treatments had a statistically significant effect on peroxidase activity of crop. Mean Peroxidase activity was higher 3.75 in pots made up of control treatment however, minimum peroxidase activity was recorded in pots receiving Drought at Grain Filling (3.26). Farmyard Manure treatments showed maximum mean POD activity in T_2= FYM @ 20 t/ha i.e. 4.17, followed closely by FYM @ 25t/ha 3.48, and statistically, the activity of peroxidase was lowest in T_0=Control (No FYM) which was 3.02. Statistically non-significant interaction activity was observed between drought and Farmyard Manure treatments

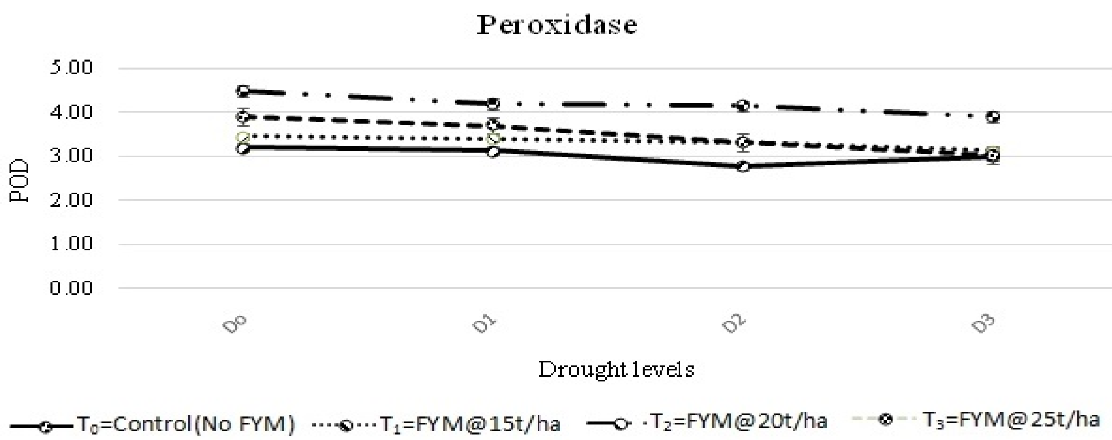

Fig 3: Effect of FYM treatments on Wheat plant POD under Drought stress

LSD for Drought = 0.20 **LSD for FYM** = 0.20 **LSD for Drought * FYM** = 0.034

14. Superoxide Dismutase (SOD)

Superoxide dismutase activity data is represented by fig#4, which shows that drought application at different critical stages and different FYM treatments had a statistically significant effect on SDA (superoxide dismutase) of wheat crop. Mean Superoxide dismutase activity was higher (286.04) in pots made up of control treatment; however, the minimum activity of SOD was recorded in pots receiving Drought at Grain Filling (252.97). Farmyard Manure treatments showed maximum mean SOD activity in T_0=Control (No FYM), which was 285.29, followed closely by T_3= FYM @ 25 t/ha, which was 82.62, and statistically mean activity of superoxide dismutase was lowest in T_0=Control (No FYM) was equal to 242.59. Statistically significant interaction activity was observed between drought and Farmyard Manure treatments.

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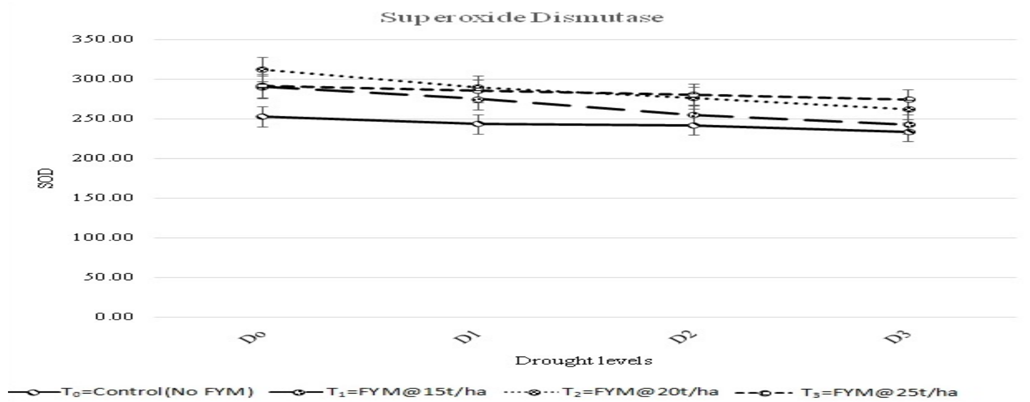

Fig 4: Effect of FYM treatments on Wheat plant SOD under Drought stress

LSD for Drought = 2.45 **LSD for FYM** = 2.45 **LSD for Drought * FYM** = 0.034

DISCUSSION

Plant height indicates the crop plant growth and development during crop life cycle and points out the different factors contributing directly and indirectly towards plant growth. Optimum plant height is achieved under the most suitable conditions comprising of peak supply of nutrients and other resources. To attain maximum height directly impacts plant photosynthesis activity as, with an increase in plant height number of leaves and nodes increases too, which ultimately results in higher photosynthates and final yield. According to wire house study carried out, drought levels had a significant impact on plant height which showed that normal irrigation (control treatment) results in 7% increase in plant height as compared to other drought treatments, which supports the fact that plant growth and height increases with the increase in moisture level as it enables the plant to utilize all resources precisely. However, Farmyard Manure also acts as a source of organic fertilizer to supply many essential organic nutrients in addition to increasing soil moisture levels under stress conditions.$T_{2=}$ FYM@ 20 t/ha maximum increase 7% in plant height as compared to other treatments. This finding aligns with the study of Ebaidet al., (2000) who reported that application of Farmyard Manure at adequate rate of 20 t/ha increases the rice plant height.

Spike length is considered a major constituents of crop final grain yield. Many yield-determining factors such as spikelets per spike and number of grains per spike directly depend on spike length. An increase in spike length results in a higher population of spikelets and grain count per spike, respectively. Along with genetic characteristics, management practices also play an important part in determining spike length. The optimum moisture level is the most important factor contributing significantly towards wheat crop attributes under stress. According to our study, wheat crop spike length showed 12% lift under optimum moisture conditions as compared to drought. This result is supported by Monjeziet al., (2013) said that the availability of moisture develops long spikes. Whereas Farmyard Manure application acted as rich source of plant nutrition producing spikes with increased length of 7% at $T_{2=}$ FYM@ 20 t/ha. This finding aligns

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with the study of Ebaidet al., 2000 who reported that application of Farmyard Manure at optimum rate of 20 t/ha increases the length of rice panicle.

Grain growth degree and photosynthate accumulation can be predicted with the help of **1000- grain weight**. It helps in determining crop growth development and final grain yield. Heavier 1000 grains can be obtained by practicing conditions suitable for maximum nutrient uptake under desired moisture level as compared to water deficit conditions. Absence of water results in shrinkage of seed which produces lower weight which has direct negative impact on final grain yield. According to statistical analysis of wirehouse study data, 1000 grain weight was higher 11 times under normal irrigation as compared to water deficit conditions, whereas Farmyard Manure application $T_{2=}$ FYM @ 20 t/ha yielded an increase in 1000-grains weight by 7 times. This result agrees with the findings of Bassalet al., 2002 who reported that application of Farmyard Manure at rate of 50 m^3 /ha increases rice 1000 grain weight.

Crop growth development and response to different nutritional sources applied can be analyzed by final **grain yield**, which also points out the economic prospect of crop. All attributes discussed above have direct part in determining the grain yield and fall in one attributes causes change in values of all dependent attributes. Management practices are important to determine the crop future, particularly under stress conditions. Similarly to other attributes optimum moisture condition generates maximum result for grain yield, which can be proven by 17% increase in grain yield of wirehouse study under control conditions in comparison to water shortage conditions whereas as Farmyard Manure application $T_{2=}$ FYM @ 20 t/ha also induced increase of 11%. This result agrees with Bassalet al., (2002) who reported that the application of Farmyard Manure increases rice grain yield.

Biomass developed by crop plant body during lifecycle from consuming the available nutrients and determined as TDM (total dry matter) is known as **Biological yield**. Biological yield is made up of grain and straw yield in combination is directly relies on availability of maximum level of moisture and beneficial nutrients, which boosts up crop growth and finally biological yield. 26% high biological yield was recorded under optimum moisture conditions; however application of Farmyard Manure acted as nutritional source and boosted biological yield 12% this study is supported by results of Bassalet al., (2002). **Water use efficiency** points out the ability of crop plant how efficiently water is utilized under stress conditions. Efficient water supply is important to yield maximum return from crop growth and development. According to our wire house study, WUE results were maximum under control treatment with 6% increase, whereas Farmyard Manure acted as a water holding agent enabling crop plants to utilize water effectively, resulting in a 7% increase in WUE under T_2=FYM @ 20t/ha. This finding is similar to the study of Bassalet al. (2002), who reported FYM as a soil conditioner improving soil texture and structure (properties). **Leaf Relative Water Content** is the relative measurement of water found within plant cells. Crop plant ability to withstand drought can be accessed through physiological attributes such as Leaf Relative Water Content. Leaf-relative water contents are directly associated with CC (chlorophyll contents) and LA (leaf area), specifically

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under stress conditions. An increase in one particular component yields an increase in other dependent physiological components. Likewise, the maximum supply of water results into higher Leaf Relative Water Content performance with 5% increase, whereas the application of FYM also plays positive part in increasing the leaf relative water contents at different levels, whereas a maximum positive with a 6% increase was recorded under 20 t/ha. This finding supports the results of Farooqet al*.* (2008), stating that drought stress reduced plant growth by influencing physiological and biochemical activities.

Osmotic potential plays an important part in plant physiological activities, particularly under stress conditions. In the presence of optimum field conditions crop plant osmotic activity displayed promising progress with 6%, and Farmyard manure application also positively affected Osmotic Potential (Osmotic potential) inducing 5% increase under 20 t/ha. These findings (WPE and Osmotic Potential) supported the the results of Farooqet al*.* (2008), stating that drought stress reduces plant growth by influencing physiological and biochemical activities. Like other different physiological attributes plant photosynthesis activity is directly linked with **leaf turgor potential** which acts as a controlling agent of leaf activities, likewise Leaf Turgor Potential depends upon Leaf Relative Water Content. Higher Leaf Relative Water Content contents ensure the leaf turgidity will be higher as it helps maintain the plant leaf structure and activities. Plant leaves with higher turgidity can capture higher photosynthates, resulting in higher crop growth and development rates. Under control treatment, an optimum water supply and other essential components, including growth-promoting and soil-conditioning nutrients, enables maximum outcomes. Results analyzed from the wire house study also revealed a similar pattern with control treatment compared to drought treatments displaying a 20% increase, whereas T2= FYM @ 20 t/ha shows 12% growth. This study is in line with Farooqet al*.* (2008).

The relationship between environments (plant internal activities) and external environment, is maintained by **stomatal conductance**. Stomatal conductance controls the external environment's effect on the activities inside the plant body. Similarly, under stress conditions, particularly water deficit conditions, the opening and closing of stomata play a significant part. Closure of stomata at the right time prevents excessive loss of plant water cells. Under water stress stomatal conductivity stops due to the generation of Abscisic acid by plant roots. According to our experimental study results, control treatment increased stomatal conductance by 3%, whereas T_2=FYM @20 t/ha also displayed positive relation with Stomatal Conductance yielding a rise of 2%. This finding supports results of Farooqet al*.* (2008) stating that drought stress reduces plant growth by influencing physiological activities. Production of ROS (Reactive Oxygen Species) in high concentration is one of the most important reasons of Biochemical disturbance in crop plant under water deficit conditions (Chaves and Oliveira, 2004; Edreva, 2005). To counter the negative impact of these reducing ROS (reactive oxygen species), antioxidants enzymes (SOD, POD, CAT, APX) are produced within plant cells. SOD (superoxide dismutase) breaks down superoxide radicals into H_2O_2 and O_2. However, CAT (Catalase) and APX (ascorbate peroxidase) use ascorbate as a reducing agent to change H_2O_2 into H_2O. POD (peroxidase) also acts as an effective antioxidant by influencing cell wall expansion under stress conditions (Edreva, 2005). D_0 (control) treatment induced increase of 23% in CAT, 13% SOD, 15% POD and 37% in APX) similarly, F_2 (20 t/ha) showed boost of 18.48% in APX, 28% in POD, 15% in SOD and 60 in CAT respectively. This finding supports results of Farooqet al. (2008), stating that drought stress reduce plant growth by influencing biochemical activities.

CONCLUSION

Drought is a major abiotic threat for sustainable wheat crop production to meet the highly increasing food supply demand. Integrated management practices are the order of the day to survive. Farmyard Manure act as organic manure, which also benefits soil health by acting as soil conditioner and important micro and macronutrients and increasing water holding capacity. To gain maximum grain yield and economic benefits application of $T_{2=}$FYM @ 20 t/ha is recommended.

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