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EFFECT OF ORGANIC MANURE ON WHEAT UNDER DROUGHT STRESS CONDITION

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ABSTRACT

A pot experiment was conducted at the net house of Sher-e-Bangla Agricultural University, Dhaka during 2017-18 of rabi season to evaluate the impact of organic manure to combat drought stress of wheat. The experiment was laid out in a Completely Randomized Design (CRD) with three replications. Factor A: Different organic manure [F_0 = Control, F_1 = Cow dung 10 t ha^{-1}, F_2 = Vermicompost 7 t ha^{-1}] and Factor B: Drought in different growth stages [D_0 = Control, D_1 = Drought in crown root initiation stage (20-29 DAS), D_2 = Drought in booting stage (45-54 DAS), and D_3 = Drought in anthesis stage (55-64 DAS)]. BARI Gom-28 variety of wheat was used as test crop. Significant variation was observed on growth, yield and yield contributing parameters. In the case of interaction, the maximum plant height (27.66, 48.10, 63.15 and 78.56cm, respectively) at 20, 40, 60 DAS and at harvest; highest number of effective tillers plant^{-1} (10.33), spike length (16.12 cm), number of spikelet spike^{-1} (17.40), number of grains spikelet^{-1} (2.85), number of grains spike^{-1} (49.59), weight of 1000 seed grain (48.37 g), grain yield (4.89 g plant^{-1}), straw yield (5.18 g plant^{-1}), biological yield (10.07 g plant^{-1}) and harvest index (48.56%) were recorded from cow dung 10 t ha^{-1} with control treatment. It can be concluded that application of cow dung is effective in wheat crop to mitigate drought condition.

Keyword: Drought stress, Organic manure, Wheat, Stress condition.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the important cereal crops in the world. It is the main sources of carbohydrate and also contains a considerable amount of protein, minerals and vitamins. It is the staple food of more than 36% of the world population

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(Hasanuzzaman et al., 2017), and contributes approximately 30% of total cereal production of the world (Lobell and Gourdji, 2012). In Bangladesh, it is the second most significant grain crop after the staple grain rice, but production is much lower compared to other wheat growing countries of the world due to the fact of growing under rain fed condition (Bazzaz, 2013).

Annual production variability of wheat is estimated at ~40% which is mainly due to heat waves and drought situations in major wheat producing belts throughout the world (Zampieri et al., 2017). Crop yield is affected by various environmental variables such as water availability and temperature as well as by agronomic factors (Hatfield and Prueger, 2015).

Drought stress reduces plant growth by affecting various physiological and biochemical processes, such as photosynthesis, transpiration, translocation, and ion uptake, carbohydrate nutrient metabolism and growth promoters. It affects both elongation and expansion growth which ultimately affects the yield of plants (Farooq et al., 2009). Incorporation of soil amendments (cow dung, vermicompost, compost, biochar, poultry litter etc.) enhances soil water holding capacity, soil water permeability, saturated hydraulic conductivity (SHC), reduces soil strength, modifies soil bulk density and aggregated stability (Peng et al., 2011). Thus, the grain yield and yield components of wheat significantly increases with the application of different organic materials resulting in the compost to be the most superior one (Sarwar et al., 2007).

This research work was designed to evaluate the yield and yield components performance of wheat with incorporation of organic manures under drought stress condition and to determine the superior organic manure to adjust the drought stress in wheat.

MATERIALS AND METHODS

The pot experiment was conducted at the net house under the Agro-Ecological Zone of Madhupur Tract (AEZ-28) during the period from November 2017 to April 2018 at the Sher-e-Bangla Agricultural University Farm, Dhaka. The experiment was laid out in Completely Randomized Design (CRD) with two factors and three replications viz. Factor A: Organic manure - 3 levels viz. i) F_0 = Control, ii) F_1 = Cow dung 10 t ha^{-1}, iii) F_2 = Vermicompost 7 t ha^{-1} and Factor B: Drought stress - 4 levels viz. i) D_0 = Control, ii) D_1 = Drought in crown root initiation stage (20-29 DAS), iii) D_2 = Drought in booting stage (45-54 DAS) and iv) D_3 = Drought in anthesis stage (55-64 DAS). BARI Gom-28 variety was used as planting material. The collected soil was sun dried, crushed and sieved properly. The soil and fertilizers were mixed well before placing the soils into the pots which was filled up with 18 kg soil. Moisture meter (Model - DSMM 500) was set up in 3 different location of a pot and 3 individual data was recorded. Then its average data was recorded to have moisture percentage by gravimetric method (Table 1).

Table 1. Moisture content (%) before and after drought stress impose

Treatment	Moisture after 1st drought impose	Moisture before 2nd drought impose	Moisture after 2nd and before 3rd drought impose	Moisture after 3rd drought impose
F_0D_0	9.79	11.46	7.29	7.04
F_0D_1	4.98	12.26	8.11	7.12
F_0D_2	9.72	12.17	1.60	7.33
F_0D_3	11.02	12.07	8.67	1.87
F_1D_0	11.36	13.64	9.69	9.55
F_1D_1	7.59	13.36	11.15	9.67
F_1D_2	11.09	13.20	2.96	9.48
F_1D_3	11.52	13.61	9.79	2.92
F_2D_0	9.95	13.01	8.57	7.90
F_2D_1	5.84	13.20	9.98	8.23
F_2D_2	9.68	12.28	1.72	8.12
F_2D_3	9.78	12.83	9.57	2.21

Urea, TSP, MOP, gypsum and boric acid were applied @ 160 kg N, 92 kg P, 144 kg K, 20 kg S and 1.5 kg B per hectare, respectively. Cow dung and vermicompost were applied according to the treatment. Two-third of urea and all other fertilizers were applied at the final pot preparation as basal and the rest one-third urea was top dressed at 1st irrigation (18 days after sowing). Fertilizers were used as per the Fertilizer Recommendation Guide 2012. Cow dung and vermicompost were applied according to the treatment. All intercultural operations and plant protection measure were taken to all pots. Initial characterization of the physical and chemical was done to get an idea which soil fits better for the treatment applied (Table2).

Table 2. Initial physical and chemical characteristics of the soil

Characteristics	Value
Mechanical fractions:	
% Sand (2.0-0.02 mm)	37.00
% Silt (0.02-0.002 mm)	50.00
% Clay (<0.002 mm)	13.00
Textural class	Silt Loam
pH (1: 2.5 soil- water)	6.0

Characteristics	Value
Organic Matter (%)	2.29
Total N (%)	0.115
Available K (ppm)	0.20
Available P (ppm)	32.74
Available S (ppm)	6.52

Eight healthy seeds were placed into each pot. After germination, three healthy seedlings were allowed to grow in each pot. Plant height was measured at 20 days interval starting from 20 days after sowing (DAS) and continued up to harvest. Number of effective tillers plant^{-1} were counted from the pots after harvesting and finally averaged. The spike length (cm) was measured with a meter scale from the plants of each pot and the average value was recorded as plant^{-1}. The number of spikelet were counted in each spike and average value of 10 spike was used to determine the number of spikelet spike^{-1}. The number of grains were counted in each spike and averaged and then expressed as number of grains spikelet^{-1}. The number of grains were counted in each spikelet and averaged and then expressed as number of grains spike^{-1}. One hundred (100) grains from each pot were randomly selected and weighed by an electric balance after sun dried and then convert weight to 1000 seed grain. The dry weight of the grain and straw yield of the three plants were recorded, and then divided by 3 for the final yield. Grain yield and straw yield were all together regarded as biological yield. Harvest index was calculated by using following formula:

Harvest index (%) = (Grain yield/Biological yield) × 100

Climatological data during the experimentation period was as under (Table 3)

Table 3. Meteorological data during the study period

Month	Temperature			Humidity		
	High	Low	Average	High	Low	Average
November 2017	32°C	19°C	26°C	100%	33%	65%
December 2017	29°C	15°C	22°C	100%	28%	74%
January 2018	26°C	10°C	18°C	100%	25%	68%
February 2018	34°C	15°C	24°C	99%	20%	57%
March 2018	34°C	16°C	28°C	100%	18%	57%
April 2018	35°C	20°C	28°C	100%	16%	66%

The experimental data were compiled and tabulated in proper form and were subjected to statistical analysis. Analysis of variance was done following the computer package MSTAT-C program and the mean differences among the treatments were adjusted by Least Significant Difference (LSD) test at 5% level of significance (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Plant height

The plant height was significantly influenced by the application of organic manures, drought stress conditions and its combination at different growth stages of the crop (at 20, 40, 60 days after sowing (DAS) and at harvest (Table 4). At 20, 40, 60 DAS and at harvest, plant height was observed comparatively higher with the application of organic manures (24.84, 35.77, 56.60 and 78.42 cm, respectively) followed by the application of vermicompost 7 t ha^{-1} (21.16, 33.64, 52.09 and 67.46 cm, respectively) and application of no organic manure (18.26, 31.90, 43.95 and 54.87 cm, respectively).

At 20, 40, 60 DAS and at harvest, the plant height comparatively higher with the pots treated with imposing no drought condition (23.31, 34.97, 53.72 and 75.07 cm, respectively) followed by drought in booting stage (45-54 DAS) treatment (21.27, 32.45, 50.09 and 70.44 cm, respectively). The lower plant height was recorded (17.83, 28.11, 42.62 and 61.17 cm, respectively) from the pots treated with drought in anthesis stage (55-64 DAS). This result corroborates the findings of Shao et al. (2008) who stated that drought affects both elongation as well as expansion growth, and inhibits cell enlargement more than cell division.

At 20 DAS, the tallest plant (27.66 cm) was observed from the treatment combination of cow dung 10 t ha^{-1} with no drought condition which was statistically similar with the treatment combination of cow dung 10 t $ha^{-1}$with drought in booting stage (45-54 DAS) and the shortest (18.95 cm) from the pots treated with no organic manure and drought in anthesis stage (55-64 DAS).

At 40 DAS, the tallest plant (48.10 cm) was observed from the pots treated with application of cow dung 10 t ha^{-1} and no drought condition and the shortest (38.92 cm) from the pots treated with no organic manure and drought in anthesis stage (55-64 DAS).

At 60 DAS, the tallest plant (63.15 cm) was observed from the cow dung 10 t $ha^{-1}$and no drought condition treatment combination and the shortest (53.32 cm) from the no organic manure and drought in anthesis stage (55-64 DAS).

At harvest, the tallest plant (78.56 cm) was observed from the cow dung 10 t $ha^{-11}$and no drought condition treatment combination and the shortest (68.53 cm) from the no organic manure and drought in anthesis stage (55-64 DAS) treatment combination.

Table 4. Effect of different organic manures, drought stress and interaction on plant height of wheat under pot experiment, mention the year of experiment

Treatments	Plant Height (cm)			
	20 DAS	40 DAS	60 DAS	At harvest (104 DAS)
Organic manures				
F_0	18.26 c	31.90 c	43.95 c	54.87 c
F_1	24.84 a	35.77 a	56.60 a	78.42 a
F_2	21.16 b	33.64 b	52.09 b	67.46 b
$LSD_{0.05}$	0.29	0.21	0.22	0.23
Drought stress				
D_0	23.31 a	34.97 a	53.72 a	75.07 a
D_1	19.65 c	30.69 c	47.24 c	65.88 c
D_2	21.27 b	32.45 b	50.09 b	70.44 b
D_3	17.83 d	28.11 d	42.62 d	61.17 d
$LSD_{0.05}$	0.32	0.24	0.25	0.25
Interaction effect of organic manure and drought stress				
F_0D_0	21.29 f	40.15 g	55.21 f	70.35 fg
F_0D_1	19.73 g	39.33 h	54.13 g	69.13 gh
F_0D_2	20.51 fg	39.74 gh	54.67 g	69.74 g
F_0D_3	18.95 h	38.92 hi	53.59 gh	68.53 h
F_1D_0	27.66 a	48.10 a	63.15 a	78.56 a
F_1D_1	26.12 b	47.28 b	62.07 b	77.34 b
F_1D_2	26.88 ab	47.69 ab	62.61 ab	77.95 ab
F_1D_3	25.34 c	46.87 bc	61.53 c	76.73 bc
F_2D_0	24.49 cd	44.11 d	59.28 d	74.34 d
F_2D_1	22.93 de	43.29 ef	58.20 e	73.12 ef
F_2D_2	23.71 d	43.70 de	58.74 de	73.75 de
F_2D_3	22.16 e	42.88 f	57.66 ef	72.51 f
LSD $_{(0.05)}$	0.78	0.41	0.54	0.61
CV (%)	5.68	4.32	5.06	6.11

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

F_0 = Control, F_1 = Cow dung 10 t ha^{-1}, F_2 = Vermicompost 7 t ha^{-1}

D_0 = Control, D_1 = Drought in crown root initiation stage (20-29 DAS), D_2 = Drought in booting stage (45-54 DAS), D_3 = Drought in anthesis stage (55-64 DAS)

Number of effective tillers plant^{-1}

The number of effective tillers plant^{-1} of BARI Gom-28 was influenced significantly by the application of organic manures, drought stress imposition and combination of both the treatment (Table 5).

The number of effective tillers plant^{-1} was observed comparatively higher with the application of cow dung 10 t ha^{-1} (8.33) followed by the application of vermicompost 7 tha^{-1} and control pots treated pots had the lowest value (4.00). The number of effective tillers plant^{-1} was observed comparatively higher with the application of no drought condition (control) pots (9.67) followed by the pots in drought in booting stage (45-54 DAS)$_2$ and the pots treated with drought in anthesis stage (55-64 DAS) produced the lowest (5.00). This result supports the findings of Shao et al. (2008) who stated that drought affects both elongation as well as expansion of growth, and inhibits cell enlargement.

The pots treated with the application of cow dung 10 t ha^{-1}and no drought condition produced the highest number of effective tillers plant^{-1} (10.33) followed by the application of cow dung 10 t ha^{-1}and drought in booting stage (45-54 DAS)$_2$, cow dung 10 t ha^{-1} and drought in crown root initiation stage (20-29 DAS)D$_1$ and cow dung 10 t ha^{-1}and drought in anthesis stage (55-64 DAS) while, the pots treated with no application of organic manure and drought in anthesis stage (55-64 DAS) produced the lowest (3.00)..

Spike length

The spike length of BARI Gom-28 was influenced significantly by the application of organic manures, drought stress imposition and combination of the both treatment (Table 5). The highest spike length was observed with the application of cow dung 10 t ha^{-1} (14.61 cm) and the lower from the no organic manure application (11.44 cm) while the application of vermicompost 7 t ha^{-1} showed the intermediate level of spike length. The spike length was observed comparatively higher with the application of no drought condition (15.22 cm) which was statistically similar with the treatment-imposed drought in booting stage (45-54 DAS) and the lowest spike length was observed from the drought in anthesis stage (55-64 DAS) (11.86 cm). This result supports the finding of Akram et al. (2002) who reported that spike length was significantly affected by increasing moisture stress.

The highest spike length was observed (16.12 cm) from the treatment interaction of cow dung 10 t ha^{-1} and no drought condition followed by the cow dung 10 t ha^{-1} and drought in booting stage (45-54 DAS) and cow dung 10 t ha^{-1} and drought in crown root initiation stage (20-29 DAS) while, the lowest spike length (10.13 cm) was observed from the no organic manure application with drought in anthesis stage (55-64 DAS).

Number of spikelet spike^{-1}

The number of spikelet spike^{-1} was influenced significantly by the application of organic manures, drought stress imposition and combination of the both treatment (Table 5). The number of spikelet spike^{-1} was observed comparatively higher (16.33) from the application of cow dung 10 t ha^{-1}followed by the application of vermicompost 7 tha^{-1} and the lower number of spikelet spike^{-1} was observed (12.67) from the pots treated with no organic manure. The number of spikelet spike^{-1} was observed higher (17.67) from the pots treated with no drought conditions followed by drought in booting stage (45-54 DAS) treatment and the pots treated with drought in anthesis stage (55-64 DAS) produced the lowest (13.00) number of spikelet spike^{-1}. The treatment interaction cow dung 10 t ha^{-1}with no drought conditions pots produced the highest number of spikelet spike^{-1} (17.40) while, the application of no organic manure with drought in anthesis stage (55-64 DAS) produced the lowest number of spikelet spike^{-1} (7.33).

Number of grains spikelet^{-1}

The number of grains spikelet^{-1} influenced significantly by the application of organic manures, drought stress imposition and combination of the both treatment (Table 5). The number of grains spikelet^{-1} was observed comparatively higher (2.56) from the application of cow dung 10 t ha^{-1}followed by the application of vermicompost 7 tha^{-1} and the no organic manure produced the lower (1.67) value. The number of grains spikelet^{-1} was observed comparatively higher (2.78) from the pots treated with no drought condition followed by the drought in booting stage (45-54 DAS) and drought in crown root initiation stage (20-29 DAS) treatment while, the drought in anthesis stage (55-64 DAS) treatment produced the lower (1.67). This result supports the findings of Chaves et al. (2002) who reported that moisture stress decrease plant height, number of tillers, number of grains and 1000-grain weight.

This result support the result of Rahman et al. (2009) who reported that the application of organic manure increased grain yield of wheat. The number of grains spike^{-1} was observed comparatively higher from the pots treated with no drought conditions (49.60) followed by the drought in booting stage (45-54 DAS) and drought in crown root initiation stage (20-29 DAS) while, the drought in anthesis stage (55-64 DAS) treatment produced the lower (21.67). This result supports the findings of Chaves et al. (2002) who reported that moisture stress decrease plant height, number of tillers, number of grains and 1000-grain weight. The pots treated with the application of cow dung 10 t ha^{-1} with no drought condition produced the highest number of grains spike^{-1} (49.59) and the application of no organic manure with drought in anthesis stage (55-64 DAS) produced the lowest (12.22).

Table 5. Effect of different organic manures, drought stress and treatment interaction on yield attributes of wheat

Treatments	Number of effective tillers plant^{-1}	Spike length (cm)	Number of spikelet spike^{-1}	Number of grains spikelet^{-1}	Number of grains spike^{-1}
Organic manures					
F_0	4.00 c	11.44 b	12.67 c	1.67 b	21.12 c
F_1	8.33 a	14.61 a	16.33 a	2.56 a	41.75 a
F_2	6.67 b	13.08 ab	14.33 b	2.11 ab	30.24 b
$LSD_{0.05}$	1.06	0.72	1.04	0.51	0.69
Drought stress					
D_0	9.67 a	15.22 a	17.67 a	2.78 a	49.06 a
D_1	6.33 bc	13.66 b	14.33 c	2.11 ab	30.24 c
D_2	8.00 ab	14.68 ab	15.67 b	2.33 ab	36.56 b
D_3	5.00 c	11.86 c	13.00 d	1.67 b	21.67 d
$LSD_{0.05}$	1.81	0.61	0.68	0.80	0.91
Interaction effect of organic manure and drought stress					
F_0D_0	5.00 e	11.76 g	10.00 h	2.22	22.23 j
F_0D_1	4.00 e	10.73 h	9.00 i	2.00	18.00 l
F_0D_2	4.33 e	11.34 g	9.67 h	2.11 de	20.40 k
F_0D_3	3.00 f	10.13 i	7.33 j	1.67 f	12.22 m
F_1D_0	10.33 a	16.12 a	17.40 a	2.85 a	49.59 a
F_1D_1	8.33 b	15.06 b	16.00 c	2.81 ab	46.24 c
F_1D_2	9.00 b	15.52 b	16.80 ab	2.83 ab	47.54 b
F_1D_3	8.00 b	14.44 c	15.33 d	2.78 abc	42.57 d
F_2D_0	7.67 bc	13.75 d	14.33 e	2.56 bc	36.64 e
F_2D_1	6.67 d	12.79 e	12.00 f	2.33 cd	28.00 g
F_2D_2	7.00 c	13.27 d	13.00 e	2.44 bc	31.76 f
F_2D_3	6.00 d	12.33 ef	11.00 g	2.22 d	24.46 i
LSD $(_{0.05})$	1.22	0.51	0.97	0.26	0.79
CV (%)	5.49	6.06	4.69	2.49	4.78

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

F_0 = Control, F_1 = Cow dung 10 t ha^{-1}, F_2 = Vermicompost 7 t ha^{-1}

D_0 = Control, D_1 = Drought in crown root initiation stage (20-29 DAS), D_2 = Drought in booting stage (45-54 DAS), D_3 = Drought in anthesis stage (55-64 DAS)

Weight of 1000 grain

The weight of 1000 grain was observed comparatively higher from the application of cow dung 10 t ha^{-1} (44.93 g) followed by the application of vermicompost 7 tha^{-1} and the pots treated with no organic manure observed the lowest (40.59 g). These findings support the results of Yang et al. (2004) who reported that 1000 grain weight was increased by the application of organic manure. The weight of 1000 seed grain was observed comparatively higher from the pots treated with no drought condition 45.14 g) followed by the treatment drought in booting stage (45-54 DAS) and the drought in anthesis stage (55-64 DAS) treatment produced the lowest (39.82 g). This result corroborates with the findings of Chaves et al. (2002) who reported that moisture stress decrease plant height, number of tillers, number of grains and 1000-grain weight. The pots treated with the application of cow dung 10 t ha^{-1} with no drought condition produced the highest weight of 1000 seed grain (48.37 g) followed by the cow dung 10 t $ha^{-1}$and drought in booting stage (45-54 DAS) and the pots treated with no organic manure and drought in booting stage (45-54 DAS) produced the lowest (37.47 g).

Grain yield

Grain yield was influenced significantly by the application of organic manures, drought stress imposition and combination of the both treatment (Table 6). The treatment cow dung 10 t ha^{-1} produced the highest grain yield (4.39 g $plant^{-1}$) followed by the application of vermicompost 7 tha^{-1} and the pots treated with no organic manure application produced the lowest (2.77 g $plant^{-1}$). This result confirms the findings of Rahman et al. (2009) who reported that the application of organic manure increased grain yield of wheat. The pots treated with no drought condition produced the highest grain yield (4.72 g $plant^{-1}$) followed by the drought in booting stage (45-54 DAS) treatment and the pots treated with drought in anthesis stage (55-64 DAS) produced the lowest (2.25 g $plant^{-1}$). Similar findings were also reported by Tuong et al. (2005) who reported that drought resulted to decrease in plant height, number of tillers per plant, total biomass and grain yield. The pots treated with the cow dung 10 t $ha^{-1}$and no drought condition produced the highest grain yield (4.89 g $plant^{-1}$) followed by the cow dung 10 t $ha^{-1}$with drought in booting stage (45-54 DAS) and cow dung 10 t ha^{-1} and drought in crown root initiation stage (20-29 DAS), while the lowest grain yield (2.41 g $plant^{-1}$) was observed with the application of organic manure and imposing of drought in anthesis stage (55-64 DAS).

Straw yield

The highest straw yield found from the pots treated with the cow dung 10 tha^{-1} (4.69 g $plant^{-1}$) followed by the application of vermicompost 7 tha^{-1} and no organic manures application (3.68 g $plant^{-1}$). The pots treated with no drought condition produced the highest straw yield (5.05 g $plant^{-1}$) followed by the treatment of drought in booting stage (45-54 DAS) and treated with drought in anthesis stage (55-64 DAS) that produced the lowest (2.71 g $plant^{-1}$). Application of cow dung 10 tha^{-1} and no drought condition treatment interaction produced the highest straw yield (5.18 g plant^{-1}) which was statistically similar with the application of cow dung 10 tha^{-1} and drought in booting stage (45-54 DAS). The pots treated with the application of no organic manure and drought in anthesis stage (55-64 DAS) produced the lowest (3.17 g plant^{-1}) straw yield which was statistically similar with the application of no organic manure and drought in crown root initiation stage (20-29 DAS).

Biological yield

The biological yield of BARI Gom-28 was significantly influenced by the application of different organic manures, drought stress and treatments interaction (Table 6). The application of cow dung 10 tha^{-1} produced the highest biological yield (9.08 g plant^{-1}) followed by the application of vermicompost 7 tha^{-1} and application of no organic manure (6.45 g plant^{-1}). This result is in conformity with Ahmadian et al. (2011) who reported that manure application improves the soil structure and soil moisture content, provides plant with essential elements, increases growth, number of umbrellas per plant and biological yield and finally lead to increase seed yield. The pots treated with no drought condition gave the highest biological yield (9.77 g plant^{-1}) followed by the drought in booting stage (45-54 DAS) treatment, and that of the lowest (4.96 g plant^{-1}) was recorded from the pots treated with drought in anthesis stage (55-64 DAS). This confirms the findings of Tuong et al. (2005) who reported that drought resulted to decrease in plant height, number of tillers per plant, total biomass and grain yield. The application of cow dung 10 t ha^{-1} with no drought condition treatment interaction produced the highest biological yield (10.07 g plant^{-1}) followed by the application of cow dung 10 t ha^{-1} and drought in booting stage (45-54 DAS) and the application of cow dung 10 t ha^{-1} and drought in crown root initiation stage (20-29 DAS), while the application of no organic manure with drought in anthesis stage (55-64 DAS) produced the lowest biological yield (5.58 g plant^{-1}).

Harvest index

The harvest index of BARI Gom-28 was significantly influenced by the application of different organic manures, drought stress conditions and its combination (Table 6). The treatment application of cow dung 10 t ha^{-1} produced the highest harvest index (48.35%) followed by treated with vermicompost 7 t ha^{-1}and that of the lowest (42.95%) was found at control. The pots treated with control produced the highest harvest index (48.31%) followed by the pots treated with drought in booting stage (45-54 DAS) and that of the lowest (45.36%) was found at drought in anthesis stage (55-64 DAS) condition. The result revealed that the application of cow dung 10 t ha^{-1} with no drought condition produced the highest harvest index (48.56%) which was statistically similar with the vermicompost and no drought condition$_0$ and the application of cow dung 10 t ha^{-1} with drought in anthesis stage (55-64 DAS) produced the lowest (43.19%) harvest index.

Table 6: Effect of different organic manures, drought stress and treatment combination on yield and harvest index data of wheat

Treatments	Weight of 1000 grain (g)	Grain yield (g $plant^{-1}$)	Straw yield (g $plant^{-1}$)	Biological yield (g $plant^{-1}$)	Harvest index (%)
Organic manures					
F_0	40.59 c	2.77 c	3.68 c	6.45 c	42.95 c
F_1	44.93 a	4.39 a	4.69 a	9.08 a	48.35 a
F_2	42.24 b	3.45 b	4.12 b	7.57 b	45.57 b
$LSD_{0.05}$	0.79	0.64	0.38	0.82	0.64
Drought stress					
D_0	45.14 a	4.72 a	5.05 a	9.77 a	48.31 a
D_1	41.53 c	3.21 c	3.70 c	6.91 c	46.45 c
D_2	43.67 b	3.93 b	4.39 b	8.32 b	47.23 b
D_3	39.82 d	2.25 d	2.71 d	4.96 d	45.36 d
$LSD_{0.05}$	1.11	0.57	0.61	1.07	0.69
Interaction effect of organic manure and drought stress					
F_0D_0	40.05 ef	3.12 d	3.42 d	6.54 e	47.70 b
F_0D_1	39.29 f	2. 86 e	3.25 e	6.11 e	46.81 d
F_0D_2	39.88 f	2.94 e	3. 34 d	6.28 e	46.82 c
F_0D_3	37.47 g	2.41 f	3.17 e	5.58 f	43.19 e
F_1D_0	48.37 a	4.89 a	5.18 a	10.07 a	48.56 a
F_1D_1	44.91 c	4.26 b	4.66 b	8.92 b	47.75 b
F_1D_2	46.58 b	4.40 b	4.78 ab	9.18 b	47.93 b
F_1D_3	43.77 c	3.86 c	4.31 c	8.17 c	47.24 c
F_2D_0	42.11 d	3.74 c	4.05 c	7.79 c	48.01 a
F_2D_1	40.62 de	3.39 d	3.77 d	7.16 d	47.34 b
F_2D_2	41.88 d	3.62 cd	3.94 c	7.56 d	47.88 b
F_2D_3	40.39 e	3.31 d	3.72 d	7.03 d	47.08 c
$LSD_{0.05}$	1.62	0.39	0.46	0.57	0.62
CV (%)	6.43	2.61	3.34	5.43	6.51

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

F_0 = Control, F_1 = Cow dung 10 t ha^{-1}, F_2 = Vermicompost 7 t ha^{-1}

D_0 = Control, D_1 = Drought in crown root initiation stage (20-29 DAS), D_2 = Drought in booting stage (45-54 DAS), D_3 = Drought in anthesis stage (55-64 DAS)

CONCLUSION

Considering the above results, it may be concluded that drought stress adversely affects all growth and yield related attributes. Control produced better yield and yield contributing attributes than other drought stress level, and cow dung showed better result in all aspects under drought stress than vermicompost and control treatment. However, further experimentation needs to be executed in different agro-ecological zones with more varieties under drought stress with organic manures application to reach more specific conclusion and recommendation.

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