University of Birjand

تنشهای محیطی در علوم زراعی
Environmental Stresses In Crop Sciences
Env. Stresses Crop Sci.
Vol. 15, No. 1, pp. 53-65 (Spring 2022)

http://dx.doi.org/10.22077/escs.2020.3377.1851

Original article

Effects of drought stress on agronomical traits of wheat (*Triticum aestivum* L.): A meta-analysis

M. Behdad[1*], F. Paknejad[2], A.M. Mahdavi Damghani[3], S. Vazan[4], M. Moarrefi[5]

1. Ph.D Candidate, Department of Agronomy and Plant Breeding, Karaj Branch, Islamic Azad University, Karaj, Iran
2. Professor, Department of Agronomy and Plant Breeding, Karaj Branch, Islamic Azad University, Karaj, Iran
3. Associate Professor, Environmental Sciences Research Institute, Shahid Beheshti University, Tehran, Iran
4. Associate Professor, Department of Agronomy and Plant Breeding, Karaj Branch, Islamic Azad University, Karaj, Iran
5. Assistant Professor, Department of Agronomy and Plant Breeding, Karaj Branch, Islamic Azad University, Karaj, Iran

Received 8 May 2020; Accepted 18 July 2020

Extended abstract

Introduction

Drought stress is one of the major risks to wheat production in many parts of the world. Due to its multidimensional effects, drought stress become a known concern for food security. The purpose of this study was to evaluate the effect of drought stress on agronomic traits of wheat using meta-analysis. A large number of studies have been conducted worldwide regarding effect of drought stress on crops as a major risk in cereals production. The multi-dimentional effect of drought on agronomic traits of wheat are too complex to compare using traditional methods. Therefore, meta-analysis was used in the present study to identify general trends among numerous independent drought-related studies and combine the results into one measure known as the effect size. Meta-analysis of field trials data can provides an overall view of variables affecting crop traits and precision of experimental data. The purpose of this study was to evaluate the effect of drought stress on agronomic traits and evaluating reliability of studies using meta-analysis.

Material and methods

Using scientific database of agronomic researches, 120 articles were evaluated to build a database of experimental data. The study synthesized results from 60 papers and published researches on drought effects and the database was built based on keywords such as wheat, drought stress, yield and agronomic traits. All studies that met the following criteria were included in the database: (1) available data of trial and control plots, (2) reported data of drought effect on at least one of five traits(yield, harvest index, biological yield, 1000-grain weight and grain per spike of wheat). The effect size for each datasets was calculated using cohen's index. Cohen's methodology applies differences between trial and control data as a measure of effect size. As a common measure in meta-analysis, Standard Mean Difference(SMD) used to evaluate precision and bias of experimental data of studies. I-squared measure used as estimation of heterogeneity for results of studies. An I-squared of less than 50% is usually viewed as low heterogeneity and over 50% as high heterogeneity.

Results and discussion

[*]Correspondent author: Marieh Behdad; E-Mail: mbehdad2013@gmail.com.

The results of analysis demonstrated that effect of drought stress on all mentioned agronomical traits is significant and negative. Using Cohen's index, the calculated effect size of drought stress on varies from 1.9248 to 4.4280 among traits. Grain yield had highest effect size and harvest index showed the lowest among all traits. Lower effect size in harvest index shows tolerance of the trait and it's relative sustainability during stress period.
Analysis of experiments showed a medium rate of heterogeneity in studies on grain yield, harvest index and biological yield and a higher heterogeneity in trials on 1000-grain weight and grain per spike.

Conclusion
Using meta-analysis in agronomic researches provides a framework to examine reliability and generalizability of experiments and individual studies. Drought stress affects many agronomic traits of wheat in different way in spite of statistical significance, results of many studies are not reliable and evident degrees of biases. Higher heterogeneity of experimental data shows a higher probability of bias and less trustable results in the examined researches and lower reliability of the sources for field application and generalization of the results.

***Keywords*:** Cohen index, Effect size, Environmental stress, Yield components

Table 1. Number of selected articles by traits (treatments)

Agronomical Traits	No. of Articles
Grain yield	52
Biological yield	23
Harvest index	25
1000-grain weight	36
Grain per spike	29

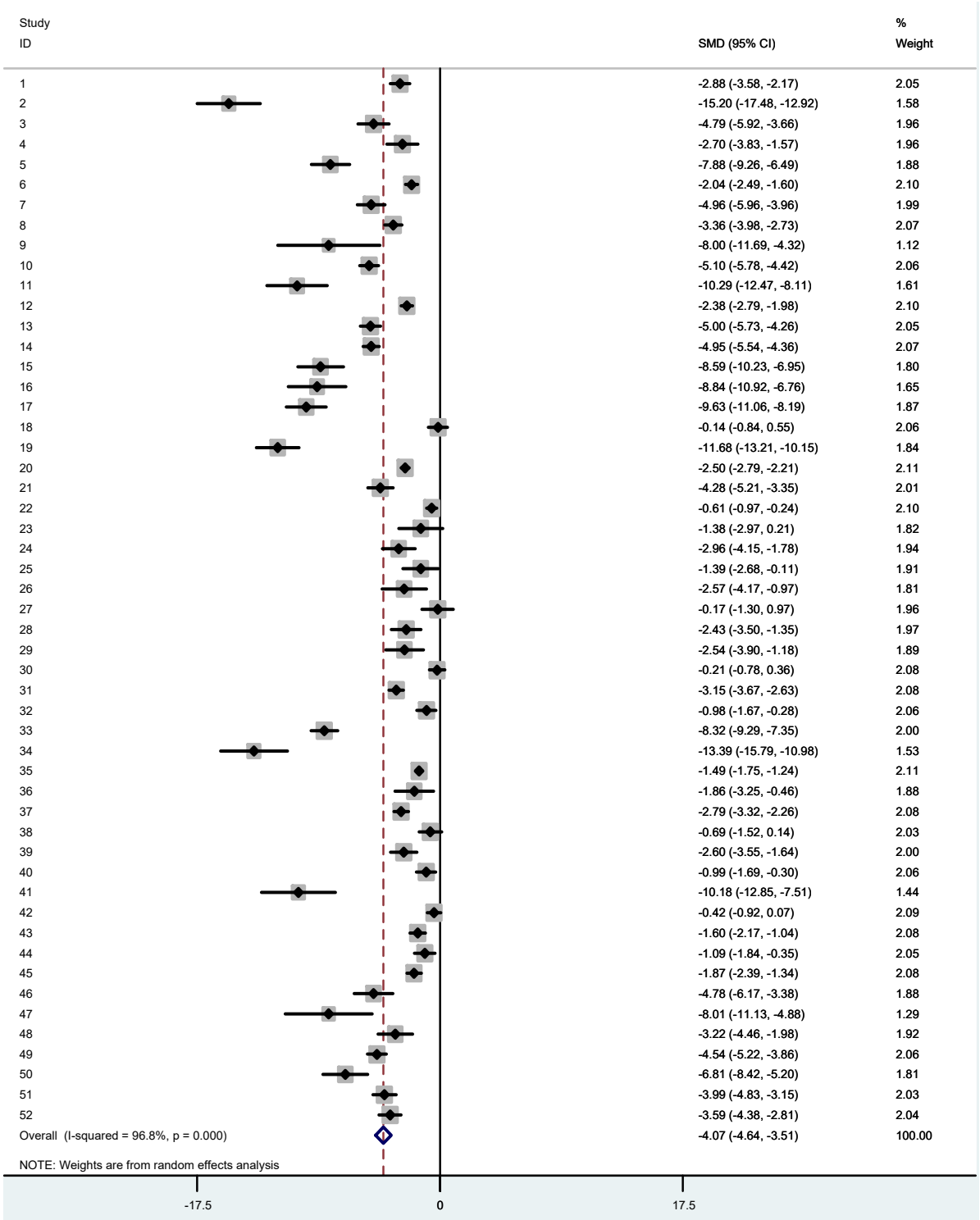

Fig 1. Forest plot of drought stress effect on grain yield shows weight of individual studies, SMD of studies with 95% Confidence Interval, I-squared of all studies and overall significance

.

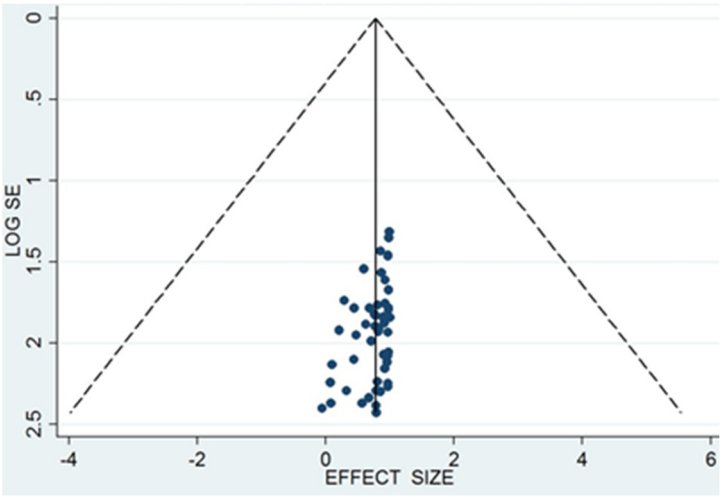

Fig 2. Funnel plot of drought stress effect on grain yield

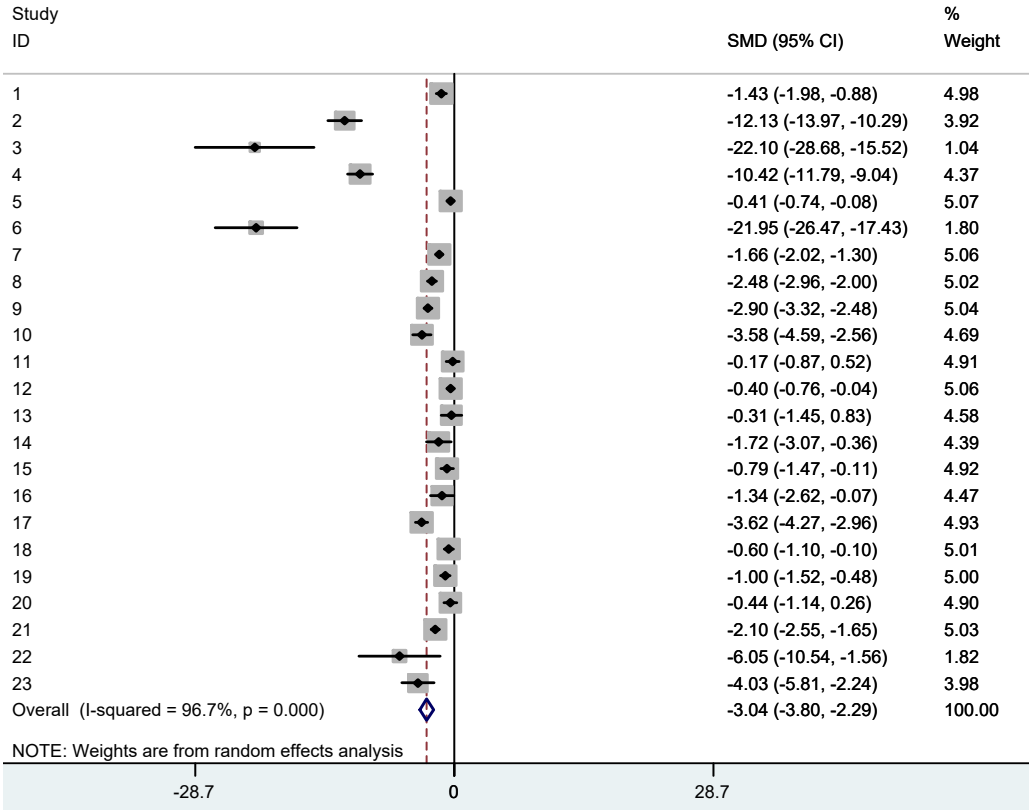

Fig 3. Forest plot of drought stress effect on biological yield shows weight of individual studies, SMD of studies with 95% Confidence Interval, I-squared of all studies and overall significance

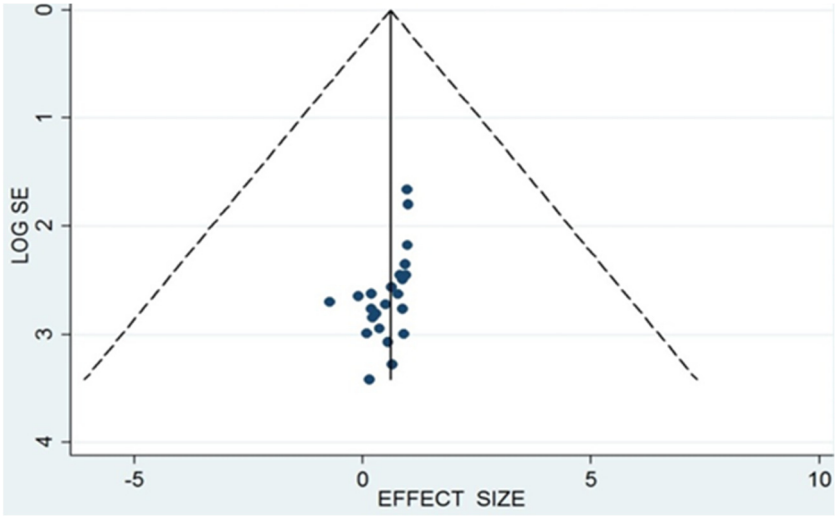

Fig 4. Funnel plot of drought stress effect on biological yield

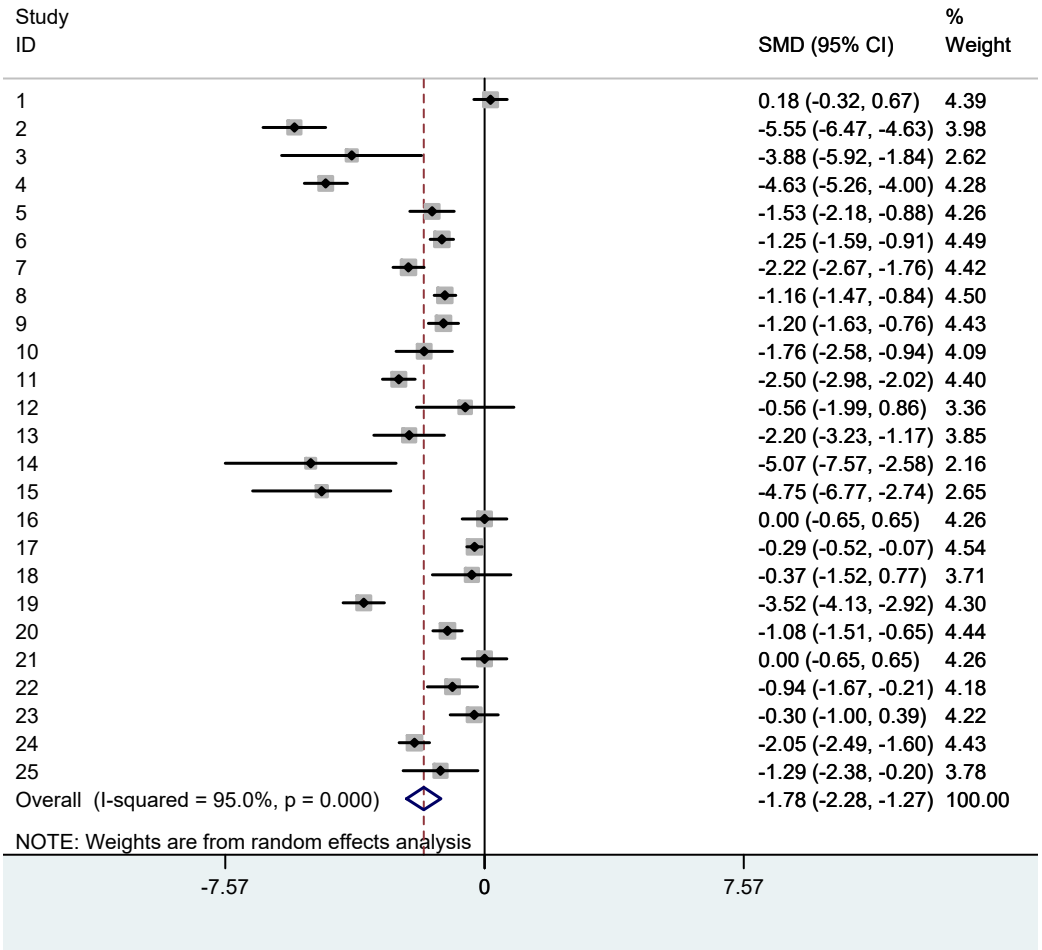

Fig 5. Forest plot of drought stress effect on harvest index shows weight of individual studies, SMD of studies with 95% Confidence Interval, I-squared of all studies and overall significance

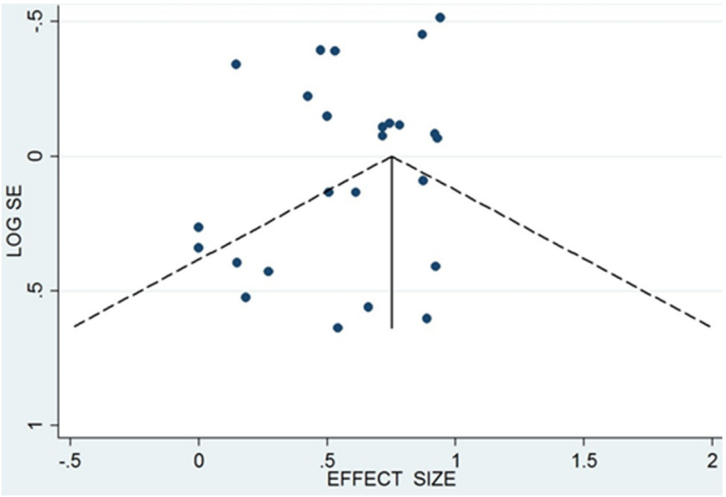

Fig 6. Funnel plot of drought stress effect on harvest index

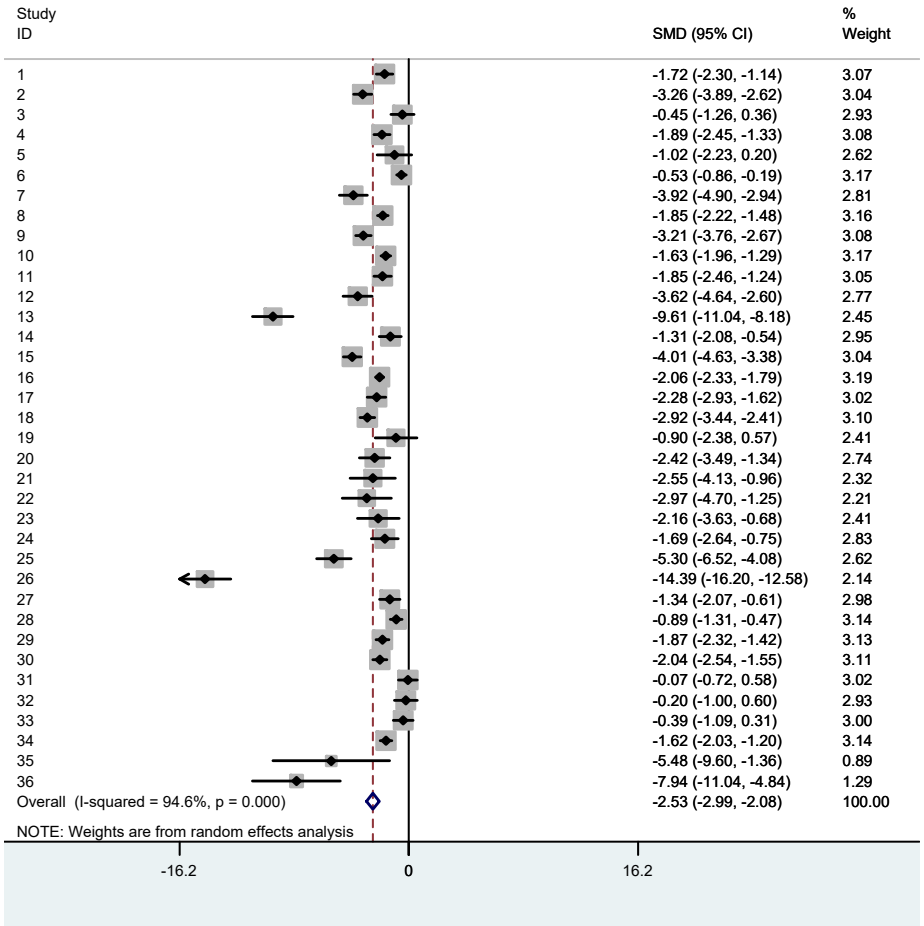

Fig 7. Forest plot of drought stress effect on 1000-grain weight shows weight of individual studies, SMD of studies with 95% Confidence Interval, I-squared of all studies and overall significance

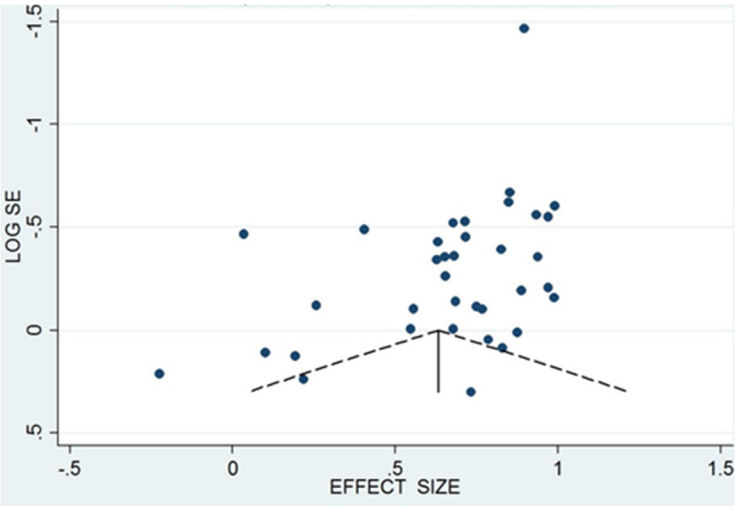

Fig 8. Funnel plot of drought stress effect on 1000-grain weight

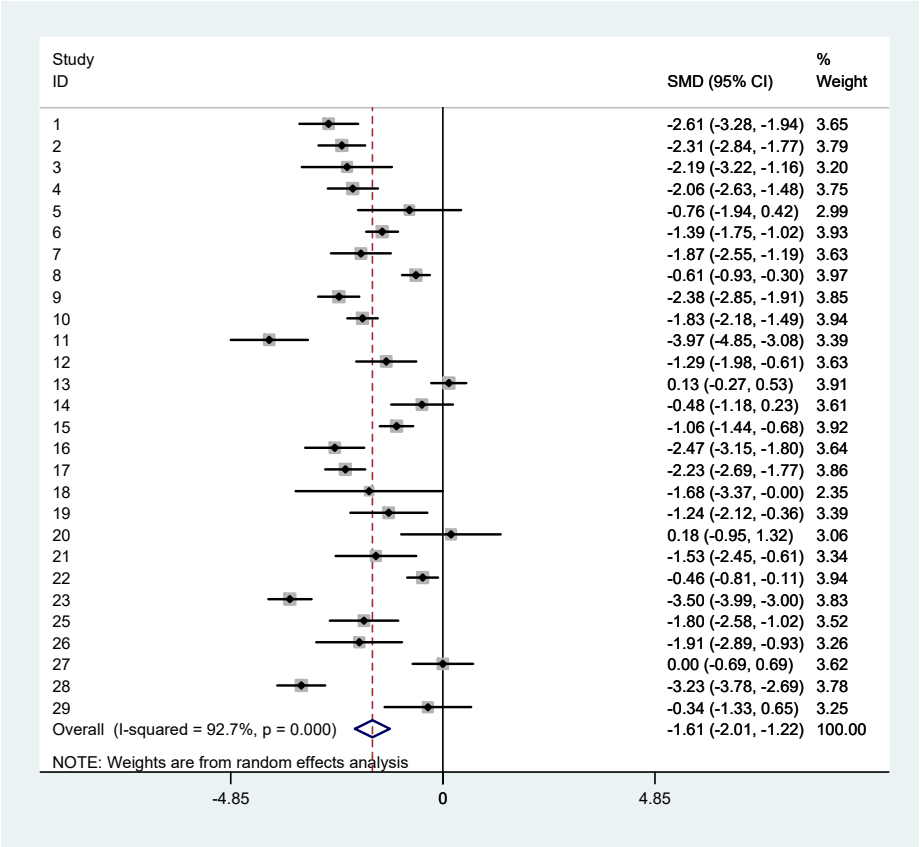

Fig 9. Forest plot of drought stress effect on grain per spike shows weight of individual studies, SMD of studies with 95% Confidence Interval, I-squared of all studies and overall significance

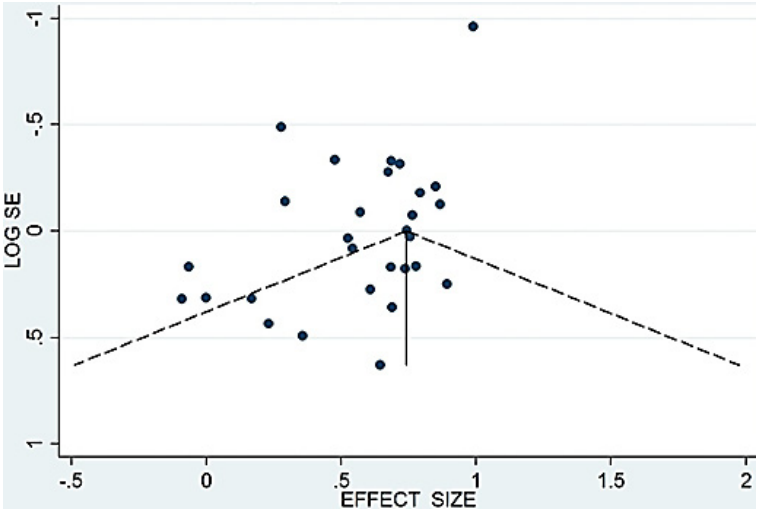

Fig 10. Funnel plot of drought stress effect on Grain per spike

Table 2. Heterogenity of studies using I-squared

Traits	Heterogenity (I-square)
Grain yield	96.8%
Harvest index	95.0%
Biological yield	96.7%
1000 grain weight	94.6%
Grain per spike	92.7%

Table 3. Summary of results and meta-analysis indices

Agronomical Traits	Standard Mean Difference (treatments)	Treatment effect		Significance Level	Cohen's "d"
		Positive	Negative		
Grain yield	-4.07(-4.64, -3.51)		*	95%	4.4280
Harvest index	-1.78(-2.28, -1.27)		*	95%	1.9248
Biological yield	-3.04(-3.80, -2.29)		*	95%	3.1277
1000 grain weight	-2.53(-2.99, -2.08)		*	95%	3.4580
Grain per spike	-1.61(-2.01, -1.22)		*	95%	3.3796