

EFFECT OF COWDUNG APPLICATION ON SELECTED SOIL HYDRAULIC PROPERTIES: A META-ANALYSIS

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Received 05th May, 2022 Accepted 20th June, 2022

ABSTRACT

Improvement of soil hydraulic attributes has been a great thematic area for decades for their influence on soil quality, environmental sustainability and ecosystem functioning. Addition/incorporation of cow dung is one of the aged practice that conditions soil system and enhances its resilience and productivity. This meta-analysis collated and analyzed results of original research findings in order to furnish a unison outcome on the effects of cow dung on porosity, hydraulic conductivity and moisture content of soil for guiding decisions on land and environmental management. Three hundred and eighty-nine original research papers from 1995 – 2021 were searched from scientific research databases to perform the meta-analysis. A two-stepwise criteria (general and specific) was adopted to exclude/include papers for prevention of bias and R – software was used for statistical analyses. Funnel and forest plots output generated were used for interpretation and inference. As indicated by forest plot, the study boxes have crossed the line of no effect to the right, thus, inferred that cow dung enhances soil saturated hydraulic conductivity (Ksat). Although, about 1/2 of the studies' boxes aligned vertically showing consistency of effect size, others were scattered to show variability as regards the extent to which cow dung increased soil Ksat. The diamond beneath the boxes shifted toward the left of the plot line OR = 30 (1.5), which indicated significance of the association as further confirmed by P value = 0.6719. Similarly, the direction of all the studies' results was on the right to the line of no effect and the diamond did not cross the vertical line, thus inferred positive significant association between cow dung and volumetric moisture content as affirmed by P value (0.4691). However, effect magnitude varied significantly. Closely similar result was observed for total porosity. Conclusively, cow dung application considerably improves hydraulic characteristics of soils but in varied magnitude largely due to climate, soil type and application rate variations.

Keywords: Meta-analysis, cow dung, soil hydraulic attributes, association and magnitude

Introduction

Soil hydraulic characteristics such as porosity, hydraulic conductivity, infiltration rate, moisture content, etc. behave in a dynamic way over space and time particularly when the soil is under beneficial human interferences as, tillage, grazing, traction etc. (Omotade and Alatis, 2017; Koorevaar *et al.*, 1999). These properties are measured and often predicted in a quantitative manner with a view to sustaining enhanced

productivity and production inputs efficiencies. Interplay among existing landuse, climate, and bio-edaphic factors control this properties, invariably (Brady and Weil, 2017; Hillel, 2004). Because of their influence on two-way fluxes and dynamics of matter and energy knowledge about them is critically required for optimum management of soils under both rain-fed and irrigated production system as well as for sustenance of watersheds, catchments and

rangelands productivity (Adaiku, *et al.*, 2020; Hillel, 2004). In cropping systems, the key objective of soil hydraulic properties investigation relates to improvement and maintenance of optimal aeration, water circulation, and biota functionality (Adekiya, *et al.*, 2016; Odunze, 2017). Owing to the significance of soil hydraulic characteristics in agro-systems, information through journal and conference manuscripts, working guides and manual, and book chapters are sufficiently available.

Application of cow dung has been a long-term practice for improving soil productivity (Adaikwu, 2020, Zaman, *et al.*, 2017; Abhishek *et al.*, 2014; Miller and Donahue, 1992). Perhaps, because it's cheap, available and accessible to farmers especially for smallholder farming, homestead gardening and suburban agriculture for enhancing crop yield and soil resilience capacity (Francisco, 2019; Zaman, *et al.*, 2017). Cow dung composes of excreta of cattle from the undigested residue of ingested feed and urine in 3:1 ratio (Gupta, *et al.*, 2019) as well large and diverse microbial population. Chemically, it composes of lignin, cellulose and hemicellulose and about 24 minerals notably; nitrogen, potassium, sulphur, iron, magnesium, copper, cobalt and manganese (Gupta, *et al.*, 2019; Li, *et al.*, 2011; Rasoulzad and Yaghoubi, 2010) thus, a resourceful management input. A good number of scientific investigations on the effect of cow dung on soil hydro-physical properties has been carried out (Jia, *et al.*, 2013; Prapagar, *et al.*, 2012; Li, *et al.*, 2011; Zhang, 2008; Tuli, *et al.*, 2005; Mohawesh, *et al.*, 2005); Tawfik, *et al.* (2019) and Pedro, *et al.* (2011) stated that, a well-developed meta-analysis (MA) is recognized as a reliable way for keeping soil and crop scientists and environmentalists abreast of current evidence-based scenario on the effect of cow dung application on soil hydraulic properties (Maillard and Angers (2014). This paper tried to collate, examine, synthesize and analyze past works done on the effects of cow dung on soil hydraulic characteristics for the purpose of crop production and soil management in a bid to draw concrete conclusions for policy making and soil management decisions.

MATERIALS AND METHODS

Publication Sourcing

All papers (389) considered for this MA were sourced through narrow search strategy using cow dung, cattle dung, cow manure, soil physical properties as keywords as suggested by Pedro, *et al.* (2011); Maillard and Angers (2014); Dao, (2019).

Database Searching

In order to access quality peer reviewed papers, the following databases were adequately explored and consulted as suggested by Gehad, *et al.* (2019) and Pedro, *et al.* (2011):

GoogleScholar, ResearchGate, AGORA, TEAL, Scopus, Z – Library, Soil Science Society of Nigeria (SSSN), Soil Science Society of America (SSSA) and African Journal Online (AJOL). Thesis and dissertation results were obtained from the libraries of the Department of Soil Science, ABU, Zaria.

Application of Selection Criteria

A pre-designed two-stepwise criteria was employed for including/excluding all the research articles for the MA so as to avoid subjectivity as recommended by Heidy and Randy (2021); Gehad, *et al.* (2019), Dao, *et al.* (2019).

General Applicability Criteria

1. Research works must be empirical rather than theoretical
2. Results must be quantitative
3. Research focus must be on the same construct and examine similar relationship i.e. examining the effect of cow dung on soil hydraulic properties.
4. Only presented results that are analyzable statistically were considered
5. Based on the goal of the work, findings of all the research must be comparable.

Specific Inclusion/ Exclusion Criteria

1. Experiments should be conducted in the field or screen house and the treatment should include cow dung/manure, no biasedly compared with a control (no cow dung)

2. Multi locational trials must comprise of both treatment and control in all the locations
3. A given trial should be under similar soil and climatic conditions and management practice
4. Data comparing the effect of cow dung, mixed with inorganic fertilizer, e.g. (e.g. cowdung + NPK, cowdung + UREA) were accepted provided it is a short term trial, because inorganic fertilizer affects soil physical properties negligibly over short time.
5. Treatments must be replicated at least three times and mean values shown along with a standard deviation (*SD*) or standard error (*SE*).
6. Results from single trial which considered different rates of cow dung or measured single rate effect at varying soil depths were individually considered provided it captured comparator/control accordingly.
7. Only full text and abstract which contained mean values were considered.

8. Only result findings presented in English language within 1995 to 2021-year bracket were considered.

Statistical Analysis

Meta-analysis was conducted using R statistical package (Pedro, *et al.*, 2011). During running of the analysis random effect model was selected to satisfy heterogeneity assumption (Tawfik, 2019).

RESULTS AND DISCUSSION

Effect of Cow Dung Application on Saturated Hydraulic Conductivity (*K_{sat}*)

It could be observed in Figure 1 that; the studies were dominantly in one side showing non-symmetry plot. This depicted that, a fraction of the studies was outweighed by the larger fraction in determining the pooled outcome. However, the *P* value of 0.0512 means the non-symmetry was very slight. This can be further deduced from the position of three dots which are close to the vertical line of the funnel plot. (Duval and Tweedie's Trim-and-Fill = 3 (to right), 3 (to left) of means. Also, it indicated missed publication results of small weight effect.

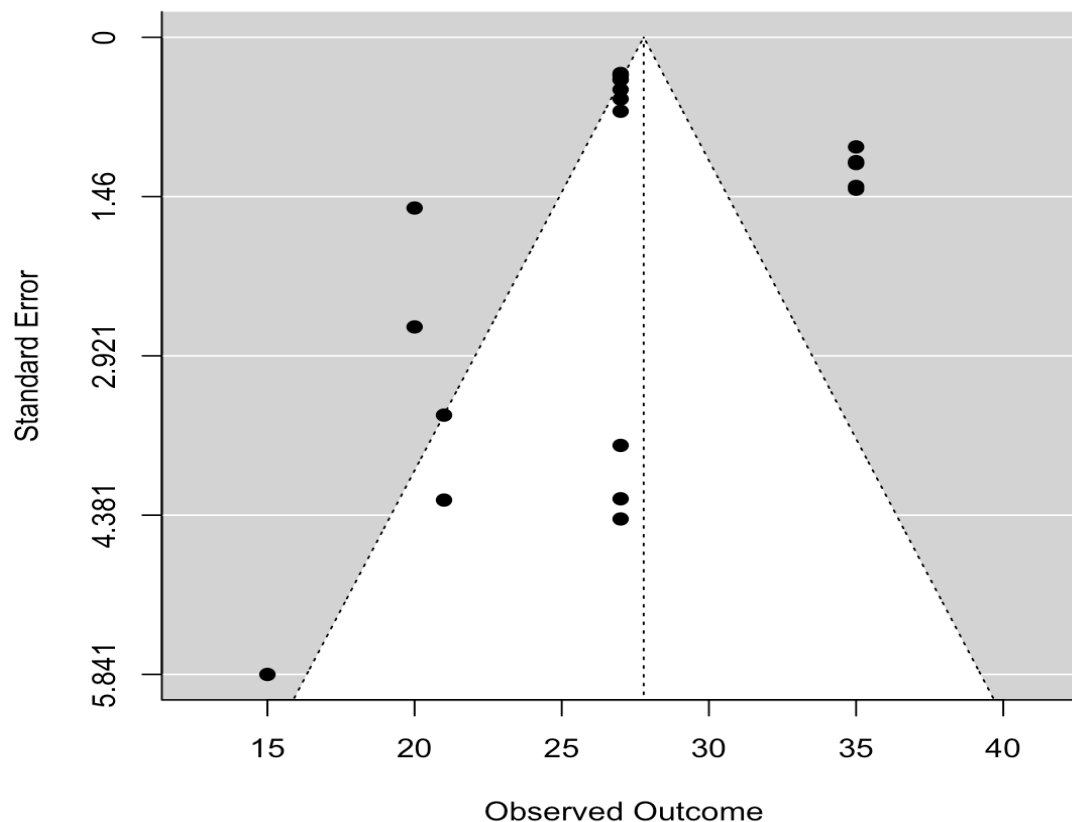


Fig. 1. Funnel Plot indicating symmetry of the publication for Saturated Hydraulic Conductivity response to cow dung.

From the forest plot below (Figure 2), it was deduced that, application of cow dung enhanced saturated hydraulic conductivity of soil, since all the study boxes have crossed the line of no effect to the right. Although, about 11 of the 21 studies' boxes clearly aligned vertically showing consistency or agreement of their results, the remaining 10 were scattered in

different directions, indicating variability as regards the extent to which cow dung increased soil *Ksat*. The diamond beneath the boxes shifted toward the right of the plot line $OR = 30$ (1.5), which indicated significance for the association as the diamond did not equalized in both sides. That was further confirmed by the P value = 0.6719 which was greater than 0.05.

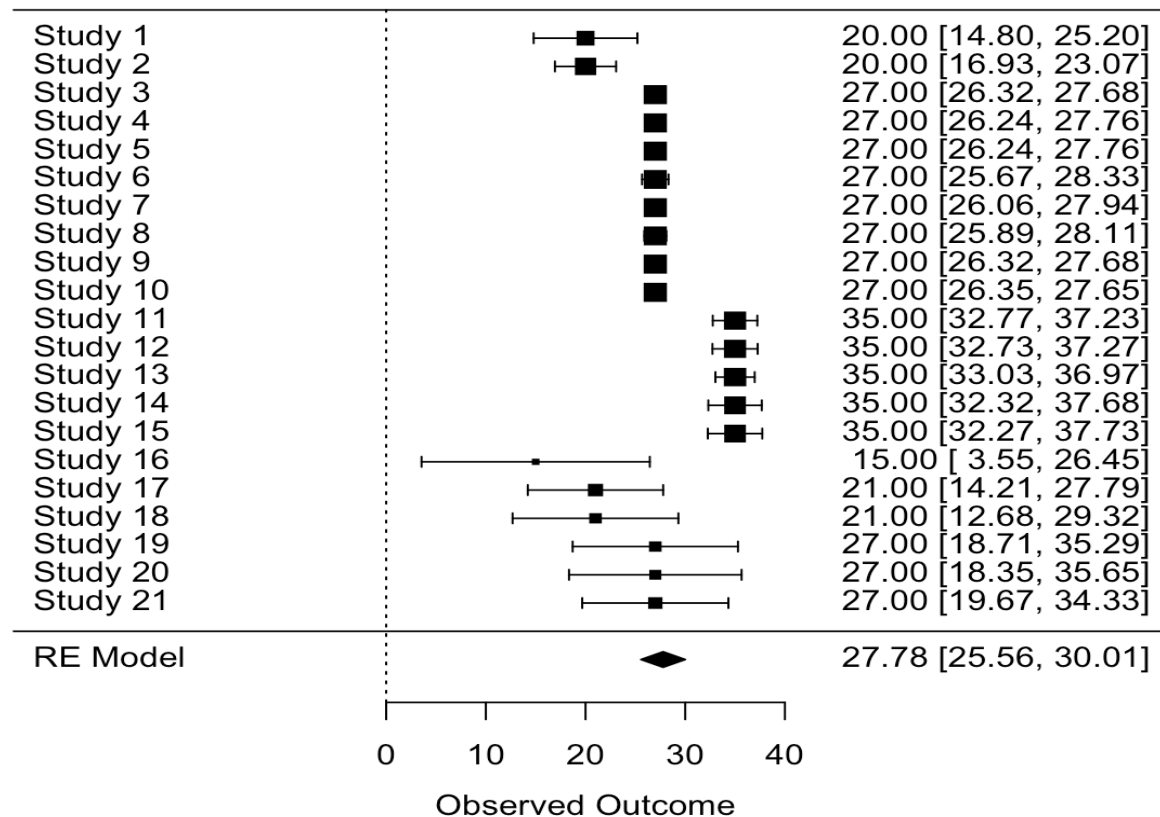


Fig. 2. Forest plot showing the weight, magnitude and direction of the studies

Effect of Cow dung Application on Soil Moisture Content

Since the P value = 0.041 is less than 0.05, the funnel was unsymmetrical. The distribution of the dot clusters was not uniform across the two sides (dense cluster in the left and

light cluster in the right of inverted funnel). Hence, it can be inferred that, there is publication bias as per the effect of cow dung on soil moisture status. Mostly medium publication result were suppressed. (Duval and Tweedie's Trim-and-Fill showed large number of values away from mean (27 to right of the funnel), 18 to its left).

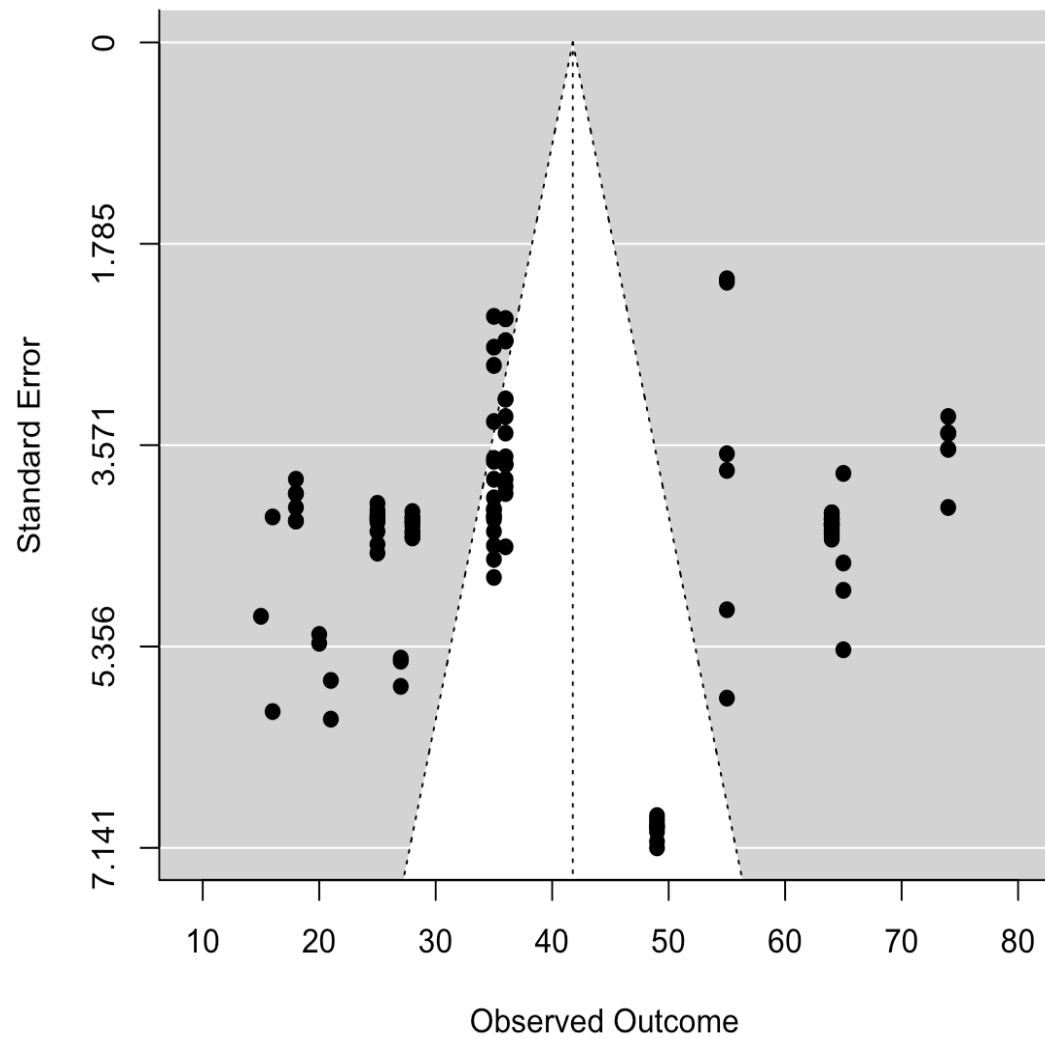


Fig. 3. Funnel Plot indicating symmetry of the publication for moisture content response to cow dung

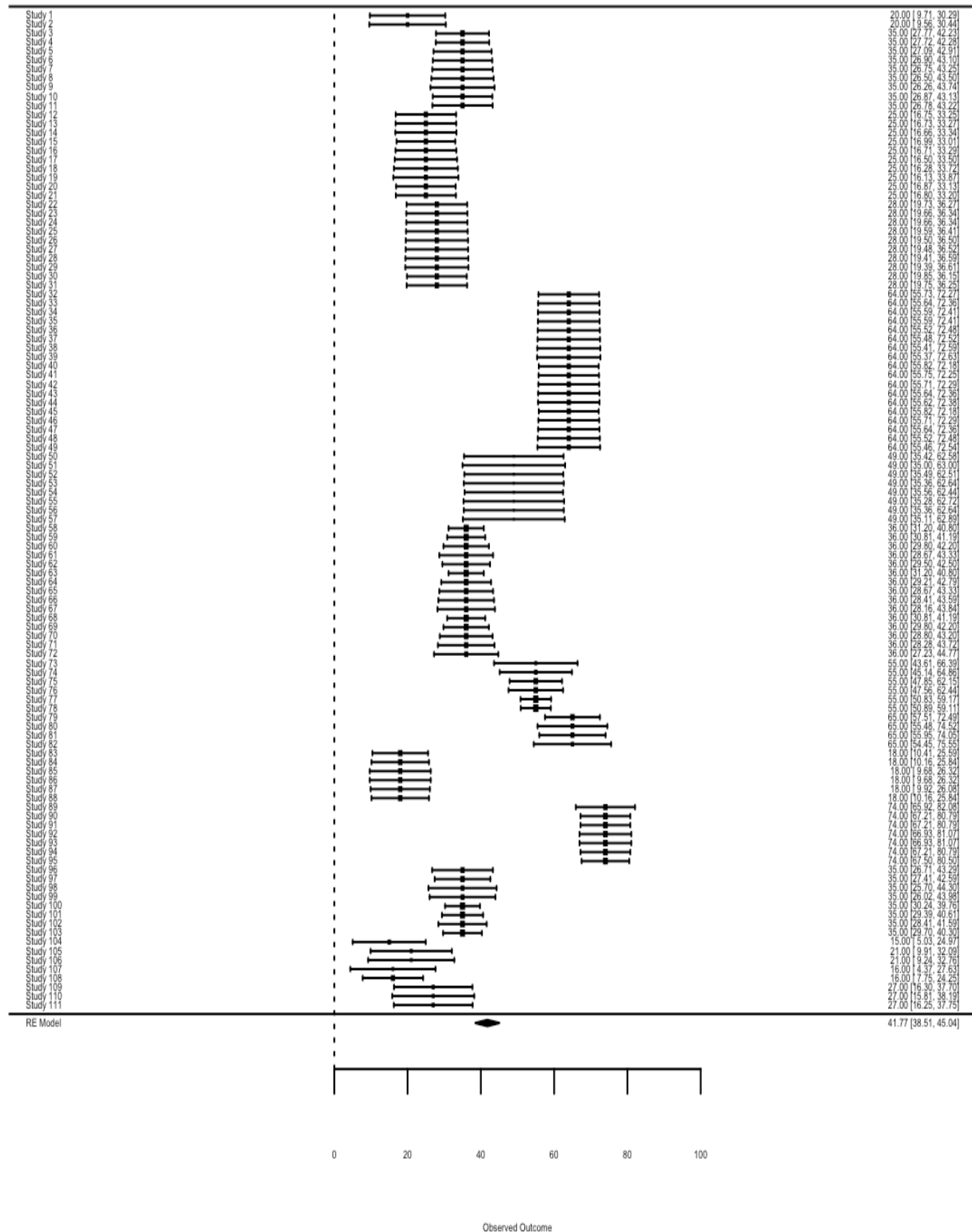


Fig 4. Forest plot showing the weight, magnitude and direction of the studies

In the forest plot above, the direction of all the studies was homogenously on the right position of the line of no effect. This is further confirmed by the position of the diamond which did not cross the vertical line, inferring significant association between cowdung application and volumetric moisture content. However the magnitude varied significantly. The variation as regards the degree to which the application of cow dung increases soil moisture varied significantly deducible from the intricate alignment of the various studies boxes. Considering the diamond's position (tilted more to the left) it implied that, association between cow dung application and soil moisture status was established. Further affirmed by P value higher than 0.05 (0.4691).

Effect of Cow Dung Application on Total Porosity

A P value of 0.2968 was recorded, which signified that, the studies were symmetrically distributed across the two sides of the funnel plot confirming absence of publication bias in determining the outcome of the meta analysis for soil total porosity (Fig. 5). Duval and Tweedie's Trim-and-Fill result indicated that five (5) studies skewed to the right of the triangle against the normal means. Scatter dots indicated close to homogenous representation of large, medium and small effect size research.

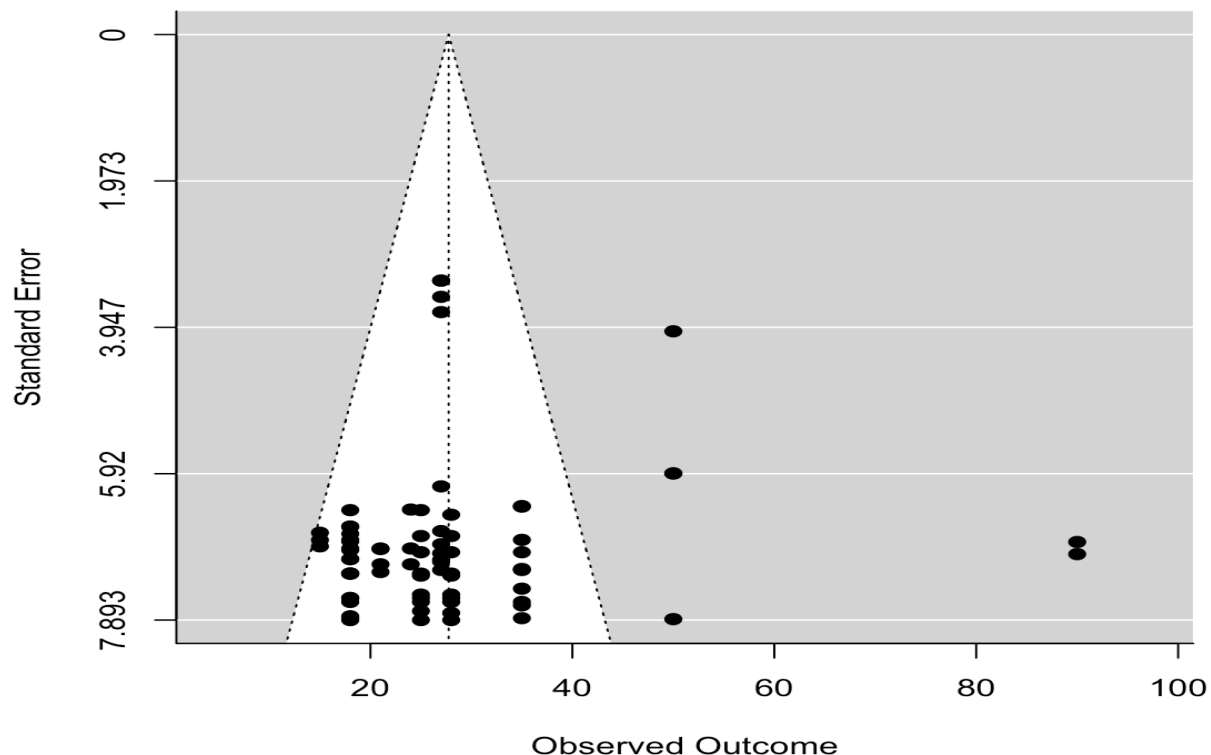


Fig. 5 Funnel Plot indicating symmetry of the publication for soil porosity response to cow dung

Majority of the research outcomes indicated low increase in total soil pores due to cow dung treatment. This can be realized by the position of majority of the studies boxes which were closer to the line of no effect (Fig. 6). The diamond position which is closer to the lower

values $OR = 0.5$ signified established association between the treatment and the response factors. Obviously many of the result boxes aligned in somewhat closely similar vertical position which depicted concord among the research results. Simply, amending soil with cow dung slightly

and gradually improved soil total porosity. P value = 0.3083. (Duval and Tweedie's Trim-and-Fill = 0 (to right), 5 (to left) of means.

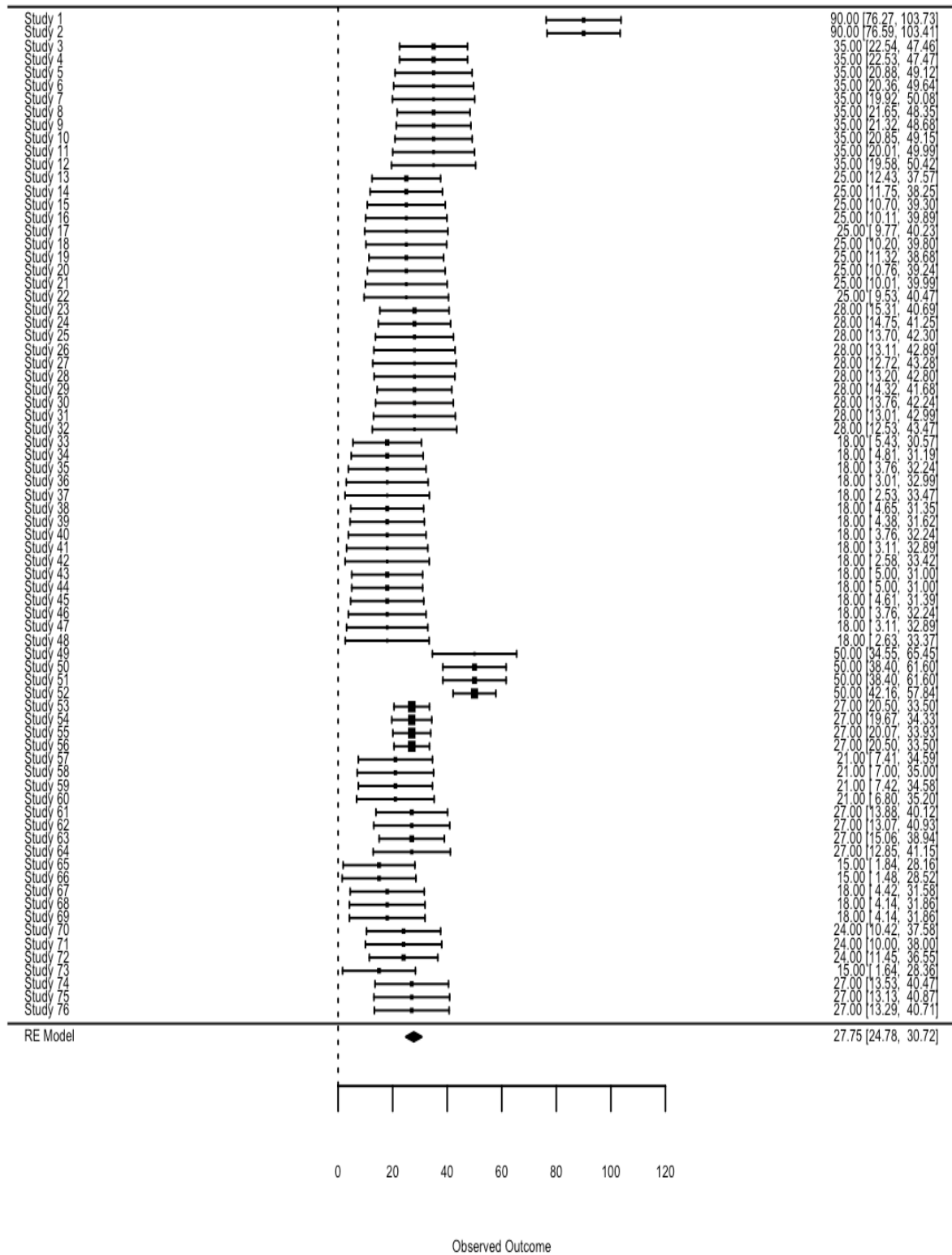


Fig 6. Forest plot showing the weight, magnitude and direction of the studies of cow dung effect on porosity

DISCUSSION

As shown in the results section application of cow dung highly increased moisture content of soils, although varied in magnitude of the effect size. The effect size variability maybe connected to application of different cowdung rates as well as variation of soil characteristics. Michael and Dunn, (2000), Celik, (2005) and Brady and Weil, (2014) opined that different soil types respond differently to management system. FAO, (2005) confirms that, the use of cowdung amendment improve soil structural quality and aggregate stability thus enhancing soil moisture content which may be due to direct application of the cowdung (Angers, 2014). Usman and Kundiri, (2016) also corroborated that platy and blocky structure and soft-hard consistency of cowdung support its ability to hold more water, thus its incorporation into soil affects soil moisture status appreciably. Adaikwu, *et al.*, (2020) noted that application of cow dung has great restorative capacity when applied to degraded land.

Similarly, hydraulic conductivity was significantly affected by cowdung amendment at varying magnitude. High amount of lignin, and spongy amorphous material in cowdung may be responsible for enhanced retention capacity of the soil as well as the ease with which water move into the soil. Idris, (2019) had earlier reported that cowdung deposit increases permeability through improving soil tilth and averting surface crusting phenomenon of soils. For total porosity, however, the pooled results showed small effect size homogenously which may be attributed to the ability of humic acid component of cowdung to provide good binding force for aggregation. Ramaru, *et al.*, (2000); Wickama and Mowo, (2001); Gachimbi, *et al*, (2002) and Usman, (2013) reported that application of cowdung to the soil improves aggregate stability and resistance to soil compaction. Organic materials added to the soil help to increase the activities and biodiversity of soil biota by serving as their source of energy and growth media (FAO, 2005).

Also, climatic heterogeneity across research locations is another factor for the varied effect magnitude. Meta- analysis result obtained by Maillard and Angers, (2014) showed that,

significant variation in soil carbon stock due to cowdung amendment between temperate and tropical climate may be responsible for effect size difference. Generally, climatic zone variation is hugely temperature and moisture driven (Freibauer *et al.*, 2004). Maillard and Angers, (2014) further reiterated that, with sufficient study results difference in land use systems and soil texture may cause effect of cowdung application on soil properties to vary in size. Ali, (1998) had noted clay dispersion phenomenon dominant in high clay soil type to as well result in effect variance.

CONCLUSION

Cowdung application considerably enhances soil total porosity, hydraulic conductivity and moisture content. The magnitude to which it exert its effect however was asymmetrical (heterogeneous) which may be connected to missing results (unpublished findings), application rate (soil/cowdung mix ratio) and consistency variations of the cowdung, climate and soil type difference.

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