IMPACT ASSESSMENT OF SOIL AMENDMENTS ON SOIL CAPPING IN MUNGBEAN PRODUCTION USING CENTRAL PIVOT IRRIGATION SYSTEM IN CLAYEY SOILS

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ABSTRACT:- A field experiment was conducted to evaluate the soil capping problem under central pivot irrigation system using different soil amendments. The experiment was laid out in randomized complete block design, replicated thrice. Mungbean (*Vigna radiata* L) variety "Dera Mung" was used as test crop. Soil amendments were carried out through pure sand and farm yard manure (FYM) in equal proportions and in three different application rates viz., 60:60, 45:45 and 30:30 kg plot^{-1} and an un-amended soil plot was kept as control. The size of each plot was 4m x 3m. The results depicted that parameters such as number of branches per plant, number of pods per plant, pod length, number of grains per pod, 1000-grain weight, and grain yield were significantly affected by different soil amendments at P>0.05, except for number of clusters per plant. Maximum of 6.2 branches plant^{-1}, 62.6 pods plant^{-1}, 8.3cm pod length, 8.9 grains pod^{-1}, and 43.3 g of 1000-grain were recorded in treatment where sand and FYM was applied to *Vigna radiata* @ 60:60 kg plot^{-1}. Moreover maximum grain yield of 1253 kg ha^{-1} was also recorded in the same treatment; however, treatments with 45:45 and 30:30 (kg plot^{-1}) ranked second and third with grain yield of 1195 kg ha^{-1} and 1153 kg ha^{-1}, respectively. It was noticed that the bulk density value of the soil was decreased from 1.754 g cm^{-3} to 1.123 g cm^{-3} when pure sand and FYM was applied @ 60:60 kg plot^{-1}.

Key Words: Vigna radiata; Farm Yard Manure; Sand; Central Pivot Irrigation System; Soil Capping; Soil Amendments; Yield; Yield Components; Pakistan.

INTRODUCTION

Center-pivot irrigation, also called circle irrigation, is a method of crop irrigation in which equipment rotates around a pivot and crops are watered with sprinklers. Center-pivot irrigation was invented in 1948 by a farmer, Frank Zybach (Javaid, 2011). It was recognized as a method to improve water distribution to fields. Central Pivot Irrigation System (CPIS) is one of the most efficient systems among pressurized irrigation systems.

CPIS is a form of overhead sprinkler irrigation consisting of several segments of pipe (usually galvanized steel or aluminum) joined together and supported by trusses, mounted on wheeled towers with sprinklers positioned along its length. The machine moves in a circular pattern and is fed with water from the pivot point at the center of the circle. Center pivots are typically less than 500m in length (circle radius) with the most common size being the standard 1/4 mile (400 m) machine. To achieve uniform application, center pivots

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require an even emitter flow rate across the radius of the machine.

For a center pivot, the terrain needs to be reasonably flat; but one major advantage of center pivots over alternative systems is its ability to work in undulating area (Moller, 2009). This advantage has resulted in increased irrigated acreage in some areas. The system is in use in parts of the United States, Australia, New Zealand, Brazil, and also in desert areas such as the Sahara and the Middle East.

Although CPIS is costly regarding initial installation but still it has advantage over other irrigation systems and irrigation water application losses like seepage, leakage and percolation experienced in surface irrigation are eliminated. Together with uniform distribution of water, it ensures supply of measured amount of water to the crop. Moreover, surface irrigation involves the digging of channels, which involves labor cost. Surface irrigation is also a source of weeds spread and soil erosion (Yan and Xu, 2002). Hence, keeping in view the water scarcity, it is direly needed to explore new ways to save water for crops and ultimately to improve the livelihood.
The soil of area where CPIS is installed is clayey in nature, though, clayey soils are not inherently bad, but can be problematic if they lack good structure. During plantation period under CPIS, soil capping was witnessed in the field, after application of irrigation through CPIS, hindering thereby the percolation of water to root zone and the crop remained stunted due to scarcity of water. Clay soils bind mineral nutrients but have poor drainage and aeration. Thus, a soil with both sandy and clayey characteristics should be optimal for plant root health. So its easy to see how the practice of adding sand to clay soils has evolved. The problems occur when sand and clay are mixed in wrong proportions. An ideal soil has 50% pore space (with the remainder consisting of minerals and organic matter).

Amendments are widely used to change physical properties of soils so that they will be more suitable for plant growth. Amendments range from chemicals such as gypsum, FYM, and selected fertilizers to bulky materials such as porous minerals, organic peats and wood shavings. The need for physical amendments is most evident in the high value crop production and ornamental nurseries where large volumes of soil mix are used daily. Moreover, large quantities of physical amendments are used in ornamental, recreational areas where substantial amounts of soil are moved for engineering and in new or altered soil areas especially arid-zone soils with relatively low organic fractions, or weak soil structure.

The company which installed the CPIS has suggested the following causes of soil capping:

- The problem occurs in soils which are mostly clayey in nature
- High electrical conductivity of soil and water
- Low organic matter contents
- Irrigation management
- Water drop impact
- Too fine tilled soil

The possible solutions for controlling infilterability is application of soil amendments (Dubey, 1998) and amendments' application seemed quite cost effective because CPIS is meant for growing high value crops on limited area.

Therefore, this experiment was designed to test possible measures for controlling infilterability by amending the soil sustainably to overcome the soil infilterability problem for sustainable high value crop production under CPIS and improve the soil fertility for ensuring quality seed production.

MATERIALS AND METHOD

To explore the best option of soil amendment for reclaiming the soil capping problem field experiments were conducted during 2011 and 2012 at PARC-Arid Zone Research Institute, Dera Ismail Khan, Pakistan.

Mungbean was planted with spacing of 30 cm and 10 cm between rows and plants, respectively. The experiment was laid out in randomized complete block design (RCBD), replicated thrice. A well-adapted mungbean variety "Dera Mung" was used as test crop. Soil was amended through mixing of sand and farm yard manure (FYM) @ 60:60, 45:45 and 30:30 kg plot^{-1}, however, plots without any amendments were treated as control. Plot size was maintained at 4m x 3 m (12 m^2). Sand and FYM were added in the soil at the time of seed bed preparation; recommended cultural practices were applied throughout the crop season.

Data were recorded on different plant parameters including number of branches per plant, plant height, number of pods per plant, number of grains per pod, and grain yield. Data were analyzed by applying Duncan's Multiple Range (DMR) Test (Steel and Torrie, 1984). Beside plant parameters, some of the Central Pivot Irrigation System parameters were also evaluated i.e., Emitter pressure (Table 1), speed of rotation trip^{-1} (Table 2) and depth of irrigation trip^{-1}, average application rate and distribution uniformity (Table 3)

Table 1. CPIS Emitter Pressure (psi)

Pressure	Discharge	Status of end gun
19 psi@ 100% speed	13 sec^{-1}(on guage)	End gun Open
22 psi@ 100% speed	14.4 sec^{-1} (on guage)	End gun Close

Table 2. Speed of Central Pivot Irrigation System at 100% run in circle

At length (ft) from pivot	Time taken (min)	Speed (ft min^{-1})
25	3.31	7.55
50	6.51	7.67

Table 3. Discharge of Central Pivot Irrigation system at 100% run in circle.

Point of discharge	Volume (m^3)	Time (min)	Discharge (m^{3}min^{-1})
Start	424.8	4:51:00	0.76
End	436.2	5:06:00	

Coefficient of variance = 11%
Average depth of water in catch can = 3 mm
Coefficient of uniformity= 88 to 94 %

The Central Pivot Irrigation system installed at Arid Zone Research Institute, Dera Ismail Khan, covers 20 acres in 6h with 100% speed and 17.02 mm depth of irrigation per round.

In total 11 irrigations were applied to the crop through CPIS, causing a total time of 23 irrigation hours. The rainfall recorded during the experiment was 201.27 mm.

RESULTS AND DISCUSSION

The impact of soil physical and chemical properties on soil capping was studied with addition of sand and compost /FYM in problematic clayey soils. The addition of soil amendment minimized soil capping by improving soil structure.

Effect of Soil Amendments on Soil Density

The results showed the decrease in bulk density as well as in particle density of the soil by addition of sand and compost/FYM (Figure 1). Bulk density is the ratio of oven dried weight of soil to its volume. Higher value of bulk density indicates that the soil is more compact having less pore space that makes it impermeable to water (Xu et al., 2000). The lower value of bulk density indicates that the soil is more porous, facilitating root respiration and water permeability (Kalkhoran et al., 2013). Data indicated that bulk density decreased due to different soil amendments and the least bulk density (1.123 g cm^{-3}) was recorded in the combination of 60 FYM: 60sand kg $plot^{-1}$ (Figure 1 and Table 4). It is

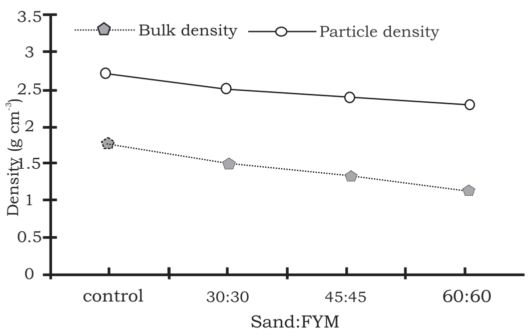

Figure 1. Effect of soil amendments on soil density

worth mentioning here that in control treatment the value of bulk density was 1.754 g cm^{-3}, similar results were reported by Mandal et al. (2009) and Javaid (2009). Improved water flow rate indicated that all amendments tested lowered the bulk density thereby reducing infilterability problem. Thus, a soil with both sandy and clay characteristics added with FYM is optimal for plant root health.

Table 4. Soil analysis of the experimental site

Parameter	(Sand: FYM)			
	Control	30:30	45:45	60:60
Bulk density (g cm^{-3})	1.754	1.510	1.350	1.123
Particle density(g cm^{-3})	2.717	2.513	2.413	2.303
Total porosity	0.213	0.332	0.381	0.452
Hydraulic conductivity (cm h^{-1})	0.361	0.350	0.388	0.388
ECe (d Sm^{-1})	5.000	3.800	3.700	4.300
pH	9.180	8.750	8.690	8.160
SAR(m mol L^{-1})½	76.20	59.50	56.00	47.00
Textural class	Clay loam	Clay loam	Clay loam	Clay loam

Effect of Soil Amendments on Soil Porosity and Hydraulic Conductivity

It can be observed that the soil porosity increases with addition of sand–FYM in the soil (Figure 2). On the other hand the hydraulic conduc-tivity of the soil first increases with addition of sand-FYM (upto 45:45) and remain unchanged with further addition of sand-FYM indicating that there has to be an optimum amount of sand-FYM amendments for specific soils.

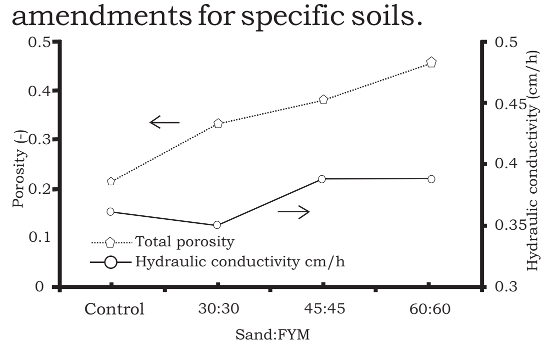

Figure 2. Effect of soil amendments on soil porosity and hydraulic conductivity

It can be noted that the ECe and pH decreases with the addition of sand-FYM up to certain limit (45:45), while ECe increases and pH decreases with further increase of sand-FYM i.e., the 60:60 treatment (Figure 3).

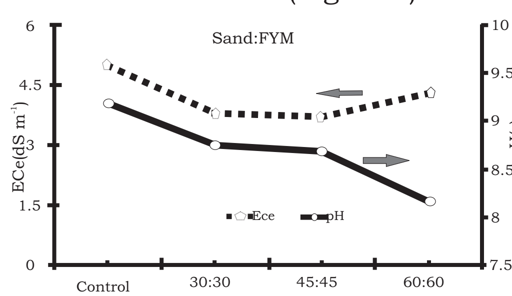

Figure 3. Effect of soil amendments on ECe and pH of soil

Sodium Adsorption Ratio (SAR) is the important factor to measure the suitability of irrigation water. The less SAR value indicates the more suitable for irrigation. The data revealed that the SAR value decreases by adding more sand-FYM to the soil (Figure 4).

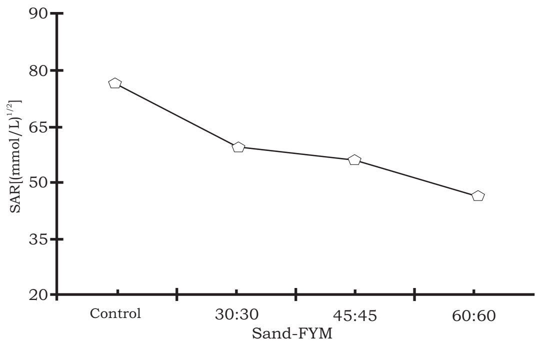

Figure 4. Effect of soil amendments on SAR of soil

The statistical analysis of the data showed (Figure 5 and Table 5) that all parameters studied were significantly

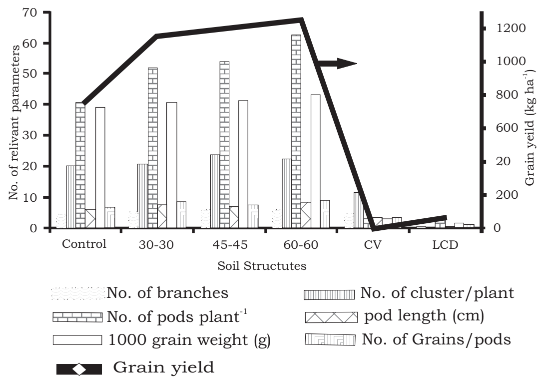

Figure 5. Effect of soil amendments on growth parameters of mungbean

increased with incorporation of different soil amendments in the clayey soil except number of cluster plant^{-1}. Maximum branches plant^{-1} (6.2),

Table 5. Effect of soil amendments on growth parameters of mungbean crop

Treatments	No. of branches plant^{-1}	No. of cluster plant^{-1}	No. of pods plant^{-1}	Pod length (cm)	1000 grain weight (g)	Number of Grains pod^{-1}	Grain yield (kgha^{-1})
Control	4.6 c	20.1	40.8 c	6.2 d	39.2 bc	6.6 c	750 c
30-30	5.1 b	20.9	51.9 b	7.6 b	40.4 bc	8.5 a	1153
45-45	5.5 b	23.8	54.0 b	7.2 c	41.6 b	7.5 b	1195
60-60	6.2 a	22.6	62.6 a	8.3 a	43.3 a	8.9 a	1253
CV	4.81	11.55	3.00	3.57	2.65	3.31	4.27
LSD	0.411	–	2.512	0.417	1.71	1.0	57.8

number of pods (62.6), pod length (8.3 cm), number of grains pod^{-1} (8.9) and 1000-grain weight (43.3 g) were recorded in the treatment that had sand and FYM applied @ 60:60 kg plot^{-1}. Maximum grain yield 1253 kg ha^{-1} was also recorded in the same treatment; however, it was followed by two statistically similar treatments with 45:45 and 30:30 sand - FYM kg plot^{-1} with grain yield of 1195 and 1153 kg ha^{-1}, respectively. Hussain et al. (2001) also reported that the best treatment regarding soil and yield improvement was the combination of gypsum+FYM. The increased yield and yield contri-buting parameters in treatment where sand: FYM was applied @ 60:60 kg plot^{-1}, seems to be due to greater amount of FYM improving soil filterability and organic matter availability. Similar results were reported by Kalkhoran (2013). Arshad et al. (2006) and Diass et al. (2008) while studying response of black gram [*Vigna mungo* (L.) Hepper] to *Bradyrhizobium japonicum* inocula-tion under different soil amendments, reported that grain yield was positively correlated with nodule biomass in FYM and NPK fertilizers amendments.

It is thus clear that addition of compost/FYM and sand minimizes the soil capping, hence improves water infiltration, though its improvement varies with soil's composition. Efficiency of irrigation system like Central Pivot Irrigation System can play a vital role in the areas where water is the most limiting factor for high value crop production whereas the potential soil capping problem is avoided by the soil amendments are discussed in this paper.

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AUTHORSHIP AND CONTRIBUTION DECLARATION

S. No	Author Name	Contribution to the paper
1.	Mr.Muhammad Mansoor	Conceived the idea, Methodology
2.	Mr. Noman Latif	Wrote abstract, Conclusion, Intoduction
3.	Mr. Zafar Islam	Technical input at every step
4.	Dr. Sher Muhammad	Over all management of the article
5.	Mr. Amanullah	Data collection, Data entry in SPSS
6.	Mr. Muhammad Umair	Result & discussion, References

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