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Effect of Korra Residue, Microbial Consortia and Inorganic Fertilizers on Chickpea Yield and Glomalin Content

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ABSTRACT

A field experiment was conducted on clay soils of Agricultural Research Station, Amaravathi, Guntur during *rabi* 2017-18 and 2018-19 to find out the influence of crop residues on glomalin content ,fungal population and percent water stable aggregates in soil on chickpea under rainfed agro-climatic condition of Krishna zone. The korra crop residue was incorporated in soil 45 days before sowing of chickpea either alone or in combination with microbial consortia and starter dose of N and P fertilizers as decomposition accelerators. Glomalin content and percent water stable aggregates assayed in soil at different crop growth stages of chickpea were significantly increased by the application of crop residue along with microbial consortia. Among the treatments, the highest glomalin content and percent water stable aggregates were recorded with the treatment $T_{7,}$ which received crop residue @1.5 t ha^{-1} + Microbial consortium@2 kg t^{-1}+ urea 3 kg t^{-1} + SSP 15 kg t^{-1} of residue incorporated to chickpea. There is a significant positive correlation between glomalin content, fungal population and aggregate stability. The dry matter accumulation at different stages and grain yield of chickpea were significantly influenced by the treatments. the highest dry matter accumulation and grain yield were recorded with 100 per cent RDF(20:50:0:40) and was at par with the treatment $T_{7,}$ which received crop residue @1.5 t ha^{-1} + Microbial consortium@2 kg t^{-1}+ urea 3 kg t^{-1} + SSP 15 kg t^{-1} of residue incorporated to chickpea during both the years of the experimentation.

Key words: *Crop residue, Dry matter, Fungal population, Glomalin content and Microbial consortium*

Glomalin is a compound in ***soil*** organic matter in the ***aggregate*** size-fractions, representing a sink of organic carbon and nitrogen. Glomalin due to its hydrophobic nature protects the soil clump from microbial degradation and erosion. Thus, glomalin act as a carbon sequester in the terrestrial carbon pool and promotes soil quality. Sharma *et al.* (2021) investigated a long-term experiment with four rates of rice straw incorporation (0, 5.0, 7.5 and 10.0 Mg ha^{-1} $year^{-1}$) and four rates of fertilizer-N (0, 90, 120 and 150 kg N ha^{-1}) application in different combinations and reported that the combined application of fertilizer-N @120 kg ha^{-1} and rice straw incorporation of 7.5 Mg ha^{-1} yr^{-1} significantly increased glomalin related soil protein in rice-wheat system in North-Western India. Singh *et al.* (2018) reported that residue retained plots had 40 and 13 per cent higher soil glomalin content compared with residue removal (290 ìg g”1) and Leucaena added plots, respectively.

Mubekaphi (2019) studied effects of different land uses on glomalin-related soil protein (GRSP) and found that glomalin is crucial for preserving soil organic matter fractions under residue retained soils. Soil aggregation refers to soil micro aggregates that are bound together by binding agents to form stable macro aggregates. Per cent water stable aggregates is considered as one of the criteria of a healthy soil. Plant roots and soil microbes release sticky organic compounds that bind soil particles together, increase plant health, and improve crop yields. Ngosong *et al*. (2010) reported incorporation of crop residues stimulated total extractable glomalin content of soil under conventional tillage. They also enable the soil to hold more water and can increase the water infiltration of the soil. Keeping this in view, the present study was conducted using korra crop residue, microbial consortium and inorganic fertilizers in chickpea crop to study the changes in glomalin content and aggregate stability.

MATERIAL AND METHODS

Field experiments were conducted for two consecutive years to study the effect of korra crop residue incorporation along with decomposing microbial consortia and fertilizers on succeeding chickpea, during 2017-18 and 2018-19 at Agricultural Research Station, Amaravathi. During *rabi*, 2017-18 and 2018-19, the experiment was laid out with eight treatments in RBD with three replications using the residue obtained from korra grown in *kharif* season. The biomass of korra obtained during *kharif* including stubbles were removed from field , chopped into 3 to 4 cm pieces and incorporated with rotovator to a depth of 15 cm of the soil in the field after quantification except in T_1 (control) and T_8 (RDF) treatments. Microbial Consortium consisting of decompo A and B was applied @2 kg t^{-1} of crop residue either alone or in combination with urea and single super phosphate as per the treatments.

Treatments:

The treatments comprised of T_1: Absolute control ; T_2: Crop residue @1.5 t ha^{-1} ; T_3: Crop residue @1.5 t ha^{-1}+ 3.0 kg Microbial consortia ;T_4: Crop residue @1.5 t ha^{-1} +1.5 kg urea + 7.5 kg SSP; T_5: Crop residue @1.5 t ha^{-1} +3.0 kg urea + 15 kg SSP ; T_6: Crop residue @1.5 t ha^{-1}+3.0 kg Microbial consortia + 1.5kg urea+ 7.5 kg SSP ; T_7: Crop residue @1.5 t ha^{-1}+ 3.0 kg Microbial consortia + 3.0 kg urea + 15 kg SSP and T_8: RDF (20-50-0-40) of N,P_2O_5 and S ha^{-1} .

Microbial consortium consists of decompo. A (fungal consortium of *Pleurotous ostreatous*, *Phanerochaete chrysosporium*, yeast & *Trichoderma*), decompo. B (bacterial consortium of *Bacillus sp*., *Lactobacillus* sp. & *Pseudomonas sp.*) developed at Agricultural Research Station, Amaravathi. The soil of experimental field used in both the seasons was clayey in texture, slightly alkaline in reaction, non saline, low in organic carbon and available N, medium in P_2O_5 and K_2O, sufficient in micronutrients. The soil samples collected at the time of sowing and at harvest of chick pea were assayed for glomalin content and per cent water stable aggregates. Glomalin extraction was performed using Bradford protein assay method. The procedure was based on interaction of a dye Coomassie brilliant blue with proteins. However, an interaction with proteins, the dye turns blue and its absorbance maxima are displayed at 595 nm. Glomalin was expressed as ìg g^{-1} of soil and the initial values were presented in table 1. Plate counts of fungi were estimated at sowing and harvest and are presented in table.2.

RESULTS AND DISCUSSION

Glomalin content

The influence of incorporation of korra crop residue along with microbial consortia and N and P fertilization on glomalin content recorded in the rhizosphere soil at different stages of crop growth in chickpea during 2017-18 and 2018-19 are presented in the table 2. The data indicated that glomalin content at all stages of crop growth was significantly influenced by the treatments and the content was increased from sowing to harvest during both the years of study.

Among the treatments, significantly the highest glomalin content was recorded in T_7 treatment which received crop residue @ 1.5 t ha^{-1} along with 3.0 kg microbial consortia and 3.0 kg urea + 15 kg SSP (290 and 297 µg g^{-1}) during 2017-18 & 2018-19, respectively at harvest and it was on par with T_3, T_5, T_6 and T_8. Significantly the lowest glomalin content was recorded in case of absolute control (T_1) (203 and 206 µg g^{-1}) at harvest during 2017-18 & 2018-19, respectively followed by T_8 which received RDF. There was a significant improvement over initial amount in treatments which received crop residue inoculated with microbial consortia and starter dose of nitrogen and phosphorus fertilizers during both the years of study. The highest per cent improvement was observed in T_7 over RDF (T_8) was 33.64 during 2017-18 and 40.75 per cent during 2018-19, respectively at harvest. The results of the present study were in tune with the findings of Singh *et al.* (2005) and Saikia *et al.* (2019) who reported residue retained plots had higher soil glomalin content compared with residue removal.

A significant positive correlation between glomalin content and fungal population at harvest (r = 0.972** and 0.958**) during both the years of study indicated that the fungal hyphae might be responsible for the production of glomalin in the rhizosphere of soil. Similarly a positive correlation between hyphal growth, symbiotic fungal glycoproteins and the improvement in the soil aggregation was reported by Rillig (2004), Caravaca *et al*. (2006) and Bedini *et al*. (2009).

Table. 1 Initial soil properties

S.No	Soil property	2017-18	2018-19	Method of analysis
1	pH	8.1	8.1	Glass electrode pH meter, Jackson (1973)
2	Electrical c0nductivity(dSm^{-1})	0.23	0.24	Conductivity bridge, Jackson (1973)
3	Organic carbon (%)	0.21	0.22	Wet digestion method, Walkley and Black (1934)
4	Glomalin ($\mu g\ g^{-1}$)	192	194	Bradford protein assay method, Wright and Upadhyaya (1998)
5	Water stable Aggregates (%)	41	42	Gravimetric method,Yoder (1936)
6	Fungal population	8×10^4	11×10^4	Serial dilution plate count, Dingra and Sinclair (2017)

Fungal population

The data on fungal population indicated that significant influence of treatments on fungal population at sowing and harvest stages of crop growth during both the years of study (Table 2). It was observed that the fungal population was decreased with the stages of crop growth and maximum activity was observed at flowering in all the treatments during both the years of study. Among the treatments, the highest population was recorded at sowing in T_7 treatment which received crop residue @ 1.5 t ha^{-1} along with 3.0 kg microbial consortia and 3.0 kg urea + 15 kg SSP (40×10^4 and 38×10^4 CFU g^{-1} soil) during 2017-18 and 2018-19, and it was on par with T_3 and T_6 which received crop residue along with microbial consortia and crop residue along with microbial consortia and starter dose of N and P inorganic fertilization, respectively. The lowest population was recorded at sowing in case of in absolute control (T_1) (18×10^4 and 19×10^4 CFU g^{-1} soil) during 2017-18 & 2018-19, respectively, followed by T_8 which received only inorganic fertilization. The improvement in fungal population at sowing in T_7 (crop residue @1.5 t ha^{-1} along with 3.0 kg microbial consortia and 3 kg urea + 15 kg SSP) over control (T_1) and RDF (T_8) were 55 and 50 per cent during 2017-18 and 50 and 47 per cent during 2018-19, respectively (Figure). Improvement in fungal activity in soil at different stages of crop growth might be due to incorporation of korra residue having wider C: N ratio material and also inoculation of residue with fungal consortia. Further, it might be attributed that addition of organic matter in the form of crop residue might release organic acids and the soil reaction decreases which resulted in increased growth of fungi. These results were corroborated with the findings of Rousk and Baath (2007) who reported improved fungal growth with incorporation of barely straw along with fertilizer N. Reardon and Wuest (2016) and Nagar *et al.* (2016) also reported similar increase in fungal population by incorporation of wheat straw.

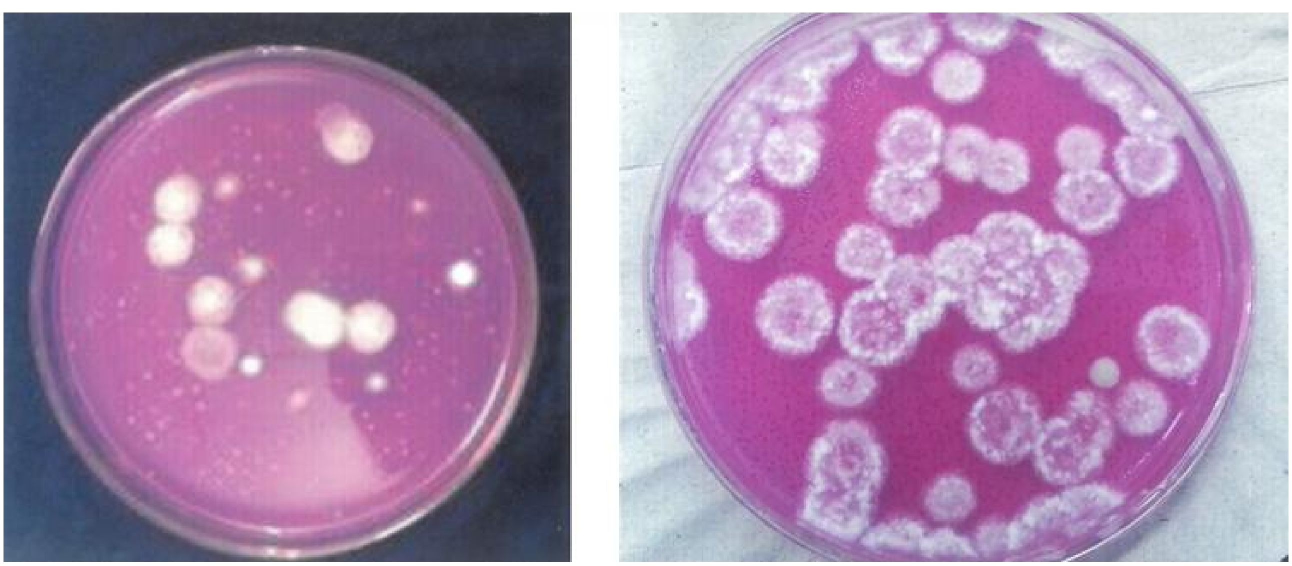
Water stable Aggregates: The per cent of water stable aggregates were not significantly improved over the initial status by the treatments both at flowering and at harvest during both the years of study (Table 2). However, the numerical improvement in aggregate stability was more prominent in treatments, which received crop residue regardless of application of consortium than the treatments, which did not receive crop residue. The treatment T_7 recorded the highest aggregate stability in both the stages of crop growth during the study and the lowest was recorded in T_1 (absolute control). Better aggregation in soil with residue incorporation might be attributed to increase in soil organic carbon and microbial biomass carbon. The non-significant effect of treatments on water holding capacity and water stable aggregates in the present study could be due to shorter time.

Dry matter: The dry matter production was significantly influenced by the treatments during both the years of experimentation (Table 3). Among the treatments, the highest dry matter was recorded both at flowering (553 and 568 kg ha^{-1}) and at harvest (1196 and 1182 kg ha^{-1}) in treatment T_8 and it was on par with T_7 at flowering during 2017-18 and 2018-19, respectively. However, the treatment T_7 was on par with T_6 and T_3 while the lowest dry matter was recorded in treatment T_1 (absolute control) at flowering (400 and 407 kg ha^{-1}) and at harvest (620 and 637 kg ha^{-1}) in the first and the second year, respectively.

Grain yield: The data presented in table 3 revealed that grain yield was significantly influenced by the treatments during both the years of study. Among the treatments, the grain yield ranged from 560 to 1097 kg ha^{-1} and from 546 to 1058 kg ha^{-1} with an average of 808 and 802 kg ha^{-1} during 2017-18 and 2018-19, respectively. The highest grain yield was recorded in treatment T_8 (RDF) (1097 and 1058 kg ha^{-1}) and the lowest was recorded in absolute control (T_1) (560 and 546 kg ha^{-1}) during 2017-18 and 2018-19, respectively. The treatments T_3 to T_7 recorded higher yields, which received crop residue either with microbial consortia or microbial consortia along with starter dose of N and P fertilization. This might be due to mineralization process and release of secondary and micronutrients along with major nutrients and better synchrony of nutrient availability slowly throughout the growth period, which resulted in better plant growth and higher yields. Starter dose of fertilization along with crop residue might have improved the soil health and consequently higher uptake of available nutrients from the soil and increased the yield components, which ultimately attributed to increased grain yield. The results are corroborated with the findings of Abbasi *et al.* (2009) and Khamadi *et al.* (2017) who reported better performance of crops in residue retained plots of mungbean with wheat residue incorporation and improvement in productivity of cereal cropping systems with the incorporation of legume residues, respectively.

Further, it was attributed that the biological nitrogen fixation by chickpea might be increased due to better activity of rhizobia because of congenial conditions in the rhizospheric soil on incorporation of korra crop residue, which led to higher crop growth and yield.

The highest glomalin content was recorded in T_7 treatment which received crop residue @ 1.5 t ha^{-1} along with 3.0 kg microbial consortia and 3.0 kg urea + 15 kg SSP. Improvement in aggregate stability was more prominent in treatments, which received crop residue regardless of application of consortium than the treatments which did not receive crop residue. The treatment T_7 recorded the highest aggregate stability in both the stages of crop growth during the study and the lowest was recorded in T_1 (absolute control).Incorporation of korra crop residue 45 days before sowing along with microbial consortia accelerated the process of decomposition and resulted in increased glomalin. This had significant effect on the growth and yield of chickpea.



T_1 – Absolute control **T_7 – crop residue @1.5 t ha^{-1} + MC+3 kg urea + 15 kg SSP**

Figure: Effect of incorporation of korra residue on fungal population of soil at flowering of chickpea

Table 2. Effect of incorporation of korra residue on glomalin content at different crop growth stages of chickpea

Treatment details	2017-18						2018-19					
	Glomalin (µg g^{-1})		Fungi (×10^4 CFU g^{-1} soil)		Water stable Aggregates (%)		Glomalin (µg g^{-1})		Fungi (×10^4 CFU g^{-1} soil)		Water stable Aggregates (%)	
	Sowing (45DAI)	Harvest (135DAI)	Sowing (45DAI)	Harvest (135DAI)	Sowing (45DAI)	Harvest (135DAI)	Sowing (45DAI)	Harvest (135DAI)	Sowing (45DAI)	Harvest (135DAI)	Sowing (45DAI)	Harvest (135DAI)
T_1: Absolute control	192	203	18	12	40	40.33	197	206	19	12	40.33	40.5
T2: Crop residue @ 1.5 t ha-1	200	224	24	15	40.6	41	217	227	24	13	41.33	41.67
T_3: T_2 + 3.0 kg Microbial consortium	243	273	33	26	41	41.67	260	284	32	19	42	43
T_4: T_2 + 1.5 kg Urea + 7.5 kg SSP	215	227	25	21	40.67	40.67	235	240	23	14	42	43
T_5: T_2 + 3.0 kg Urea + 15 kg SSP	219	242	31	20	43	42.33	241	252	30	16	42.33	43
T_6: T_3 + 1.5 kg Urea + 7.5 kg SSP	256	286	38	29	43.67	43.33	273	285	33	20	42.67	44
T_7: T_3 + 3.0 kg Urea +15 kg SSP	260	290	40	30	44.67	43.33	280	297	38	22	43.67	44.67
T_8: RDF (20-50-40) of N,P_2O_5 & S kg ha^{-1}	195	217	20	14	41	42	200	211	20	12	42	42.33
SE (m)+	13.23	13.23	2.44	1.41	1.98	1.9	13.57	13.57	2.19	1.35	2.53	1.98
CD (0.05)	40.11	40.11	7.39	4.29	NS	NS	41.14	41.14	6.64	4.09	NS	NS
CV (%)	10.25	10.25	14.82	15.31	8.21	7.77	10.18	10.18	13.98	14.58	7.79	8.01

* DAI-Days after incorporation

Table 3. Effect of incorporation of korra crop residue on yield of chickpea

Treatment details	2017-18			2018-19		
	Dry matter (kg ha^{-1})		Grain yield (kg ha-^{1})	Dry matter (kg ha-^{1})		Grain yield (kg ha-^{1})
	Flowering (45 DAI)	Harvest (135 DAI)		Flowering (45 DAI)	Harvest (135 DAI)	
T_1: Absolute control	400	620	560	407	637	546
T2: Crop residue @ 1.5 t ha-1	410	740	680	423	760	663
T_3: T_2 + 3.0 kg Microbial consortium	464	957	860	469	934	877
T_4: T_2 + 1.5 kg Urea + 7.5 kg SSP	411	783	708	457	778	690
T_5: T_2 + 3.0 kg Urea + 15 kg SSP	412	807	720	480	800	701
T_6: T_3 + 1.5 kg Urea + 7.5 kg SSP	470	1017	883	490	973	887
T_7: T_3 + 3.0 kg Urea +15 kg SSP	495	1063	963	511	1093	967
T_8: RDF (20-50-40) of N,P_2O_5 & S kg ha^{-1}	553	1196	1097	568	1182	1058
SE (m)+	22.08	52.45	48.14	25.08	53.45	42.64
CD (0.05)	66.94	159.01	145.93	76.03	162.03	129.28
CV (%)	8.47	10.12	10.31	9.13	10.35	9.2

* DAI-Days after incorporation

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