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Inclusion Effect of Fox Tail Millet in Fallow-chickpea Production System: An Approach to Improve Land Productivity in Vertisols under Variable Water Regimes

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ABSTRACT

Background: The land utilization efficiency of vertisols can be increased by inclusion of a short duration crop preceding Bengal gram in fallow-bengalgram cropping system in scarce rainfall zone of Andhra Pradesh.

Methods: A field investigation was conducted at Regional Agricultural Research Station, Nandyal, Kurnool (District), Andhra Pradesh during 2010-11, 2011-12 and 2012-13 to study the influence of including a short duration crop like foxtail millet in traditional fallow-chickpea system. The field was laid out in Split plot design and the treatments are comprised of cropping systems *i.e* foxtail millet-chickpea and fallow-chickpea as main plots and variable water regimes (with and without irrigation) as subplots.

Result: The results revealed that in deep vertisols, *kharif* fallows can be grown with a short duration crop like foxtail millet by utilising the initial rains of the season thus providing an additional income to chickpea farmer and was also observed that seed yield of chickpea taken up during rabi was not affected due to preceding foxtail millet.

Key words: Foxtail millet, Inclusion effect, Vertisols.

INTRODUCTION

In India, nearly 50% of the net cultivated area is under rainfed (Sharma, 2011) contributing 44% of the total food grain production. In general, because of low cropping intensity, the average land productivity of rainfed areas is low and mainly restricted to rainy season (*kharif*). However, in vertisols, rabi cropping is more popular and *kharif* is kept fallow. It is because, deep vertisols can be easily cultivated and tilled only within a limited soil-moisture range as they become very hard when dry and extremely sticky when wet (Krantz *et al.,* 1978) due to high in montmorillonitic clay. In addition, vertisols require more time for saturation of root zone because of less infiltration rate and the unsaturated condition of root zone during *kharif* season cannot support successful crop production. The root zone gets saturated with the rainfall received during *kharif* season and in vertisols, soil moisture can be conserved for longer periods thus favouring successful crop production on residual moisture. Hence, farmers keep land fallow during *kharif* and if any crop grown in fallow, may deplete soil moisture thus affecting chickpea yield in *rabi* season. However, hydrological studies of traditional systems on the ICRISAT farm showed that just 41% of the potentially available rainfall was actually used for evapo transpiration by a post-rainy season sorghum crop (Pathak *et al.,* 1985). Moreover, vertisols with soil depth of 185 cm has water holding capacity in the range of 230 to 300 mm (Virmani *et al.,* 1982) and provides an opportunity for double cropping to better use soil water in both seasons. A large portion of potentially productive cropland in deep black soils (vertisols) of Scarce rainfall zone in Andhra Pradesh remains fallow during the kharif season and after the monsoon, chickpea crop is grown during rabi season. However, exposure of bare land to rains and wind during kharif season may result in wind erosion and loss of soil structure there by soil degradation in the long run (Sharma, 2001). Hence, there is a need to keep the soil covered with a short duration and less water requirement crop like foxtail millet. This helps not only in maintaining soil health but also an additional income to the farmer by proper utilization of the rains during *kharif* season. The efficient utilization of these fallow lands enhance the crop productivity along with sustainable system productivity. Soil condition and climatic situation clearly indicate that short duration crop can easily be fit in that situation (Chowdhury *et al*., 2020). Thus, inclusion of a crop in the existing farmer's cropping pattern i.e in fallow land will improve soil health and the system productivity as a whole (Khan *et al*., 2018). Also, continued use of fallow-crop farming system may result in soil organic carbon (SOC) as the decomposition of SOC

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Table 1: Yield, yield parameters and economics of foxtail millet and chickpea crops under foxtail-chickpea and fallow chickpea cropping systems.

	Foxtail millet-chickpea								Fallow-chickpea							
	Foxtail millet															
	Irrigation				Without irrigation				Irrigation				Without irrigation			
	2010-11	2011-12	2012-13	Mean	2010-11	2011-12	2012-13	Mean	2010-11	2011-12	2012-13	Mean	2010-11	2011-12	2012-13	Mean
Grain yield (kg/ha)	1476	1504	1454	1478	1007	1420	1360	1262	-	-	-	-	-	-	-	-
Straw yield (kg/ha)	1952	2703	2801	2485	1268	2540	2290	2033	-	-	-	-	-	-	-	-
Gross returns (Rs/ha)	19078	19940	22316	20445	12970	18818	20643	17477	-	-	-	-	-	-	-	-
Net returns (Rs/ha) - A	12678	12540	11916	12378	6970	11818	10643	9810	-	-	-	-	-	-	-	-
	Chickpea															
Plant height (cm)	43.6	38.6	33.6	38.6	37.7	30.9	32.2	33.6	39.1	39	36.3	38.1	38.1	35.7	35.8	36.5
No. of branches/plant	24.3	25.2	17.4	22	13.8	19.2	15.7	16	16.7	28.8	16.8	21	14.6	23.5	16.4	18
No. of pods/plant	36.5	47.6	36.5	40	33.6	40.3	27.8	34	33.6	54	45.3	44	30.5	40.6	34.8	35
100 seed wt	22.2	27.2	32.2	27.2	22.7	25.9	26.4	25	22.2	28.5	33.3	28	23	27.5	30.5	27
Seed yield (kg/ha)	1226	1243	1224	1231	1104	868	1074	1015	1055	1453	1280	1263	1076	1033	1185	1098
Gross returns (Rs/ha)	30650	43505	48960	41038	27600	30580	42960	33713	26375	50855	51200	42810	26900	36155	47400	36818
Net returns (kg/ha) - B	19850	31705	34660	28738	17600	20380	29460	22480	15575	39055	36900	30510	16900	25155	33900	25652
Combined net returns (Rs/ha) A+B	32528	44245	46576	41117	24570	32198	40103	32290	15575	39055	36900	30510	16900	25155	33900	21528

is 2 to 2.5 times more in fallow as compared to cropping period (Vanden Bygaart, 2004). Moreover, growing a crop in fallows also increase the SOC through increased soil microbial activity and also addition of root portions to the soils. Hence, growing of cover crops in fallows preceding *rabi* season can be one of the efficient strategies for increasing SOC sequestration (Shah and Venkatraman, 2009). Many research studies indicated that growing a crop rather than keeping fallow resulted higher gross and net returns. Further, lack of vegetative cover during most of the rainy season exposes the surface soil to the impact of high-intensity rains, causing soil erosion (Hudson 1971) and affecting the overall productivity. Under these conditions, a short duration crop like foxtail millet can be included in double cropping as a preceding crop in fallow-chickpea production system and being a small seeded crop, can be sown when the top soil gets saturated with early rains of *kharif* and comes up with subsequent rains during the season. Our hypothesis is that growing foxtail millet in *kharif* may act a vegetative cover and favours infiltration in soil. Hence, whatever the amount of rainfall received during fallow period is efficiently trapped in soil moisture zone which can be efficiently utilised by chickpea grown on residual moisture. Keeping this in view, the present investigation was taken up to assess the effect of inclusion of foxtail millet in fallow-chickpea production system in vertisols on growth, yield and soil moisture of succeeding chickpea that is grown under rainfed and irrigated conditions.

MATERIALS AND METHODS

A field study was conducted at Regional Agricultural Research Station, Nandyal, Kurnool (Dt.), Andhra Pradesh during 2010-11, 2011-12 and 2012-13. The soil texture is deep clay with organic carbon of 0.56%, low nitrogen (205 kg/ha), high phosphorus (42 kg/ ha) and potassium (410 kg/ha). The field was laid out in split plot design comprising of four treatment combinations with fallow and foxtail millet as main plots and with and without irrigation as subplots. The treatments are imposed in large sized plots and were non replicated. During *kharif* season, in one acre of field, half acre was grown with foxtail millet and the remaining half was kept as fallow. In *rabi* season, chickpea was grown in each of the half acre plots. Irrigation was given to foxtail millet and chickpea at critical stages as per the treatment. Foxtail millet var. Srilakshmi of 70 days duration and chickpea variety JG11 of 110 days duration were used as test material. Fox tail millet was grown as rainfed with a spacing of 22. 5 cm x 10 cm and was fertilized with 40kg N and 20kg P_2O_5 applied in the form of urea, single super phosphate and muriate of potash respectively. Chickpea, taken up subsequently with a spacing of 30 cm x 10 cm was irrigated at pod formation stage as per the treatment and was fertilized with 20kg of N and 50kg of P_2O_5/ha in the form of urea and single super phosphate respectively was applied at the time of seed bed preparation. In each season, normal cultural practices and plant protection measures for

Table 2: Influence of foxtail millet-chickpea and fallow-chickpea cropping systems on soil moisture at 15-30cm depth at 25, 60 and 75 days after sowing (DAS) of chickpea in deep vertisols.

Treatments	Soil moisture (%) at 15-30 cm											
	With irrigation											
	25 DAS				60 DAS				75 DAS			
	2010-11	2011-12	2012-13	Mean	2010-11	2011-12	2012-13	Mean	2010-11	2011-12	2012-13	Mean
Foxtail millet-chickpea	20.4	20.2	16	18.9	18.4	15.6	22	18.7	14.5	23.4	22.5	20.1
Fallow-chickpea	27.7	20.4	17.5	21.9	19.6	14.8	21	18.5	14.6	24	22.5	20.4
					Without irrigation							
Foxtail millet-chickpea	29.6	21	16.4	22.3	24.6	16.1	13.5	18.1	16	12.1	12.5	13.5
Fallow-chickpea	30.5	20.7	16.8	22.7	26.4	15.4	13	18.3	15.6	12.2	13	13.6

raising successful foxtail millet and chickpea crops were followed. The amount of soil moisture at 15-30cm depth at 25, 60 and 75 DAS was estimated by gravimetric method as given by Black (1965). A rainfall of 625.6 mm, 615.7 mm and 763.4 mm was received during 2010-11, 2011-12 and 2012-13 respectively. The crops were harvested at maturity and the economics was calculated based on the prevailing market prices.

RESULTS AND DISCUSSION

From the field study, it was observed that the mean seed and straw yields of foxtail millet recorded with irrigation was (1478 and 2485 kg/ha) higher as compared to without irrigation (1262 & 2033 kg/ha respectively). Foxtail millet when irrigated, resulted in a mean net returns of Rs. 12,778 whereas, Rs. 9,810 when cultivated without irrigation.

In foxtail millet–chickpea cropping system, under irrigated situation, chickpea recorded a higher mean plant height (38.6 cm), no. of branches/plant (22), no. of pods/plant (40), 100 seed weight (27), seed yield (1231 kg/ha) as compared to unirrigated chickpea which recorded mean seed yield (1015 kg/ha), 100 seed weight (22.2 g), no. of pods/plant (34), no. of branches/plant (16) and plant height (33.6 cm).

In fallow-chickpea, mean seed yield of chickpea was 1263 and 1185 kg/ha under irrigated and unirrigated situations respectively. Also, chickpea, under irrigated situation, resulted in the mean plant height (38.1 cm), no. of branches/plant (21).

Under both the systems (*i.e.*, fallow-chickpea and foxtail millet-chickpea) yields were increased substantially with one irrigation. Higher net returns of the system were obtained when foxtail millet was introduced as preceding crop to chickpea. Under rainfed conditions, though the yields of chickpea were higher in fallow-chickpea system the mean combined net returns were higher with foxtail millet-chickpea system (Table 1). As regards the soil moisture, in all the years of investigation, under the both the systems much variation was not observed between foxtail millet-chickpea and fallow-chickpea systems at different stages of the crop (Table 2).

CONCLUSION

From the three years of study, it can be concluded that, a short duration crop like foxtail millet can be grown in vertisols during *kharif* fallow thus providing additional income to farmer and increasing land productivity. Further, the results indicate that, inclusion of foxtail millet in fallow-chickpea cropping system, will not affect the yield of chickpea grown on residual soil moisture.

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