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Crop diversification with turmeric crop for maximizing productivity, profitability and resource conservation

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Abstract : Field experiment entitled crop diversification with turmeric crop for maximizing productivity profitability and resource conservation Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut U.P. for consequently three years (2008-2011). On the basis three years of experimentations it was observed that in turmeric raised bed planting with retention of crop residue can be a potential production alternative for the semi-arid volcanic high lands. The extensive tillage with its associated high costs can be reduced by the use of permanent raised beds. Perhaps more important, its of great interest that permanent raised beds with partial residue retention for both crops take provided similar yields as with full retention. Since, there is an intense competition for residue use for fodder in many rainfed areas, especially by small and medium scale formers, it is encouraging that between 50% and 70% of the residue can be removed and with retention of the remaining portion on adequate benefit to the soil is provided. Permanent raised bed without residue retention, however is unsustainable practices leading to low crop performance and soil environmental degradation.

Keywords: Crop residue, Permanent raised beds, turmeric, productivity, profitability

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Sustainability of the turmeric crop system is one of the most vital issues in Indian agriculture and in view of the increasing cost of inputs, stagnating yields, it is pertinent to reduce the cost of cultivation so that the farmers can get competent rates in the local as well as world markets. FIRB has now emerged as one of the most successful resource conservation technology (RCT) and is presently spread to a sizable area in the turmeric based cropping system. There are two main components in the FIRB technology, the first and the foremost that has been taken care of is the perfected FIRB machine. The second one that warrants immediate attention is the the adaptability of a variety to FIRB system. At present the popular turmeric variety of the area is being planted by FIRB machines.To harvest the gains from this technology it is important that an integrated turmeric baseresearch approach be adopted towards development of specific varieties suitable for FIRB conditions.

Raised bed cultivation systems have been used since time immemorial by farmers in many parts of the world. The origin and use have traditionally been associated with water management issues,either by providing opportunities to reduce the adverse impact of excess water on crop production or to irrigate crops in semi-arid and arid regions (Sayre 2004). In most cases the traditional application of raised bed cultivation systems has involved considerable tillage operations (by hand, draft animals, or more recently machinery) to make the beds before planting the next crop and burning of crop residues or using straw for fodder (Aquino1998).These featured essentially no tillage and the mulching of crop residues on the raised bed surface (Sayre 2004). A next step to increase sustainability is to reduce tillage and manage crop residues on the surface, reusing permanent raised beds with only superficial reshaping in the furrows between the raised beds as needed before planting of each succeeding crop, following even distribution of the previous crop residues (Sayre 2004). Permanent raised beds permit the implementation of crop residue strategies to maintain a permanent soil cover for greater rainwater

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capture and conservation. Govaerts *et al.* (2005) reported permanent raised bed treatments under unirrigated conditions combined with rotation and residue retention to yield the same as the other conservation agriculture (CA) practices of zero tillage on the flat with residue retention and crop rotation over a period of 6 years. The extra advantage of permanent raised bed planting over zero tillage on the flat is that more varied weeding and fertilizer application practices are possible by trafficking in the furrow bottoms and the N fertilizer can be banded through the surface residues reducing potential N volatilization losses (Limon-Ortega and Sayre 2002). Moreover, it controls machine traffic, limiting compaction to furrow bottoms, allows the use of lower seeding rates than with conventional, flat planting systems and reduces crop lodging (Moreno *et al.* 1993).

Therefore, in 2008 a unique experiment was initiated by SVPUA&T,Meerut in a light textured soil at crop research centre to compare raised bed planting based on extensive tillage with the formation of new raised beds for each succeeding crop versus an approach where raised beds are formed for the initial crop after a final tillage cycle and are then reused as permanent raised beds with only superficial reshaping in the furrow as needed before planting of each succeeding crop. The experiment includes permanent raised bed planting with different levels of crop residue retention in order to see if those practices can increase the sustainability of the turmeric-based cropping systems in the target zone.

Materials and Methods

A field experiment was conducted for 03 years (2008-09 to 2010-11) at the crop research centre of Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, U.P., (29°4' N latitude and 77° 46' E longitude) at an elevation of 237 m above mean sea level. The climate of Modipuram is broadly classified as semi-arid sub-tropical characterized by very hot summers and cold winters. The hottest months are May-June, when maximum temperatures may shoot up as high as 45-46 °C, whereas during December-January, the coldest months of the year, the minimum temperatures often goes below 5°C. The average annual rainfall is 862.7 mm, 75-80 percent of which is received through North west monsoon during July to September. The experimental soil (0–15 cm) was sandy loam in texture, with a bulk density of 1.48 Mg m^{-3}, weighted mean diameter of soil aggregates 0.74 mm, pH =7.9, total C = 8.3 g kg^{-1}, total N = 0.83 g kg^{-1}, Olsen P = 28 mg kg^{-1}, and K = 128 mg kg^{-1} of soil as determined by procedures described by Prasad (1998).

An experiment was initiated in April 2008 with turmeric crop. The treatments aimed at evaluating resource conservation technologies consisted of three methods of seeding and four residue management method viz.,T_1 wide bed planting with residue incorpatedT_2 wide bed planting with full residue retain,T_3 wide bed planting with partial residue retain, T_4 wide bed planting withl residue removed,T_5 narrow bed planting with residue incorpated,T_6 narrow bed planting with full residue retain,T_7 narrow bed planting with partial residue retain, T_8 narrow bed planting withl residue removed,T_9 flat bed planting with residue incorpated,T_{10} flat bed planting with full residue retain,T_{11} flat bed planting with partial residue retain, T_{12} flat bed planting withl residue removedl in a complete randomized block design. Each of the treatment was replicated thrice. In residue incorporated turmeric in flat sowing and bed planting plots, 2 harrowing, 2 cultivating and 1 planking operations were performed. The sowing was done with inclined seed metering device seed- cum- fertilizer drill and multi-crop bed planter at the rate of 1000 and1250 kg ha^{-1} for raised beds and flat beds(conventional method) of turmeric, respectively.The treatments under residue management practices experiment were 80 % N as basal and 4-split of N in turmeric crop.Beds planting (narrow & wide) and flat planted the turmeric after managing the residues treatments,irrigation was applied as and when required.

Turmeric received 125 kg N as urea, 60 kg P_2O_5 as single super phosphate as basal, 60 kg K_2O as muriate of potash ha^{-l} as half as basal and half as 90 days after planting and $FeSO_4$, 30 kg as basal.. Nitrogen was applied in two ways one 80% as basal and rest as crop need and second 25 kg as basal and rest in 4 split as 30,60 90 and 120 days after planting by placement of N.Turmeric received 5-8 irrigations. Glyphosate @ 3.5 litres in 500-600 litres water per hectare was sprayed to kill green vegetation before 2 days of sowing. The crops were sown in the second week of April and harvested in the second week of March.The bulk density and moisture content of the soil was measured from 0 - 150 mm depth by core method (Black and Hartage, 1996). The soil cone index was measured by standard cone penetrometer. The N, P, K and organic carbon of soil were determined by procedure described by Prasad (1998). The mean weight diameter (MWD) of soil aggregates was measured by sieve analysis. The yield and yield attributing characters and water requirement were measured by standard procedures.

Results and Discussion

Prospects of Furrow Irrigated Raised Bed planting(FIRB) system for crop diversification

There is increasing concern about the sustainability of high input, intensively cropped; cereal dominated cropping systems in north west India. There is evidence of system productivity stagnation, nutrient and water imbalance. The ameliorative effect of including legumes in such continuous cereal dominated crops and cropping systems has long been known but, over time, legume crops have generally declined in importance with crop intensification. This is a consequence of low yield potential of legumes as compared to cereals and their susceptibility to many abiotic and biotic stresses. Consequently, legumes were perceived as risky crops, especially by resource poor farmers. However, recent advances in management techniques of legumes do raise the feasibility of their greater use in cereal-dominated systems, so as to increase crop diversification and contribute to system sustainability. The diversified agro-climatic, biophysical and socio-economic conditions of north west India suited to different crops and cropping systems have wide scope for diversification of rice-wheat cropping system. The diversification and intensification for sustained productivity of crops and cropping systems in hav north west India in practice especially with the development of new generation multi crop bed planters. The FIRB planting technique provides an opportunity for crop diversity through inclusion of various crops as well as feasibility of inter or relay cropping thereby leading to resource efficient cropping systems.Turmeric, the most important wet season spice crop in south Asia has shown potential for rice crop diversification in north west India.The introduction of FIRB planting technique in the region has shown tremendous potential for increasing the water productivity and economic growth of the farmers with the limited resources. The results of on-farm trials in north west India revealed a marked increase in water productivity and yield under vegetable-based system compared to rice based system (Naresh *et al* 2008). They reported that the water productivity and yield was further increased with FIRB planting technique compared to flat planting technique (Table 3&4).

Furrow irrigated raised bed planting system and soil properties

Soil from permanent raised beds with full residue retention had significantly higher mean weight diameter (MWD) compared to conventional tilled raised beds (Table 5). Permanent raised beds with full residue retention had a significantly higher MWD compared to those with residue removal .There was no effect of crop type on aggregation stability and distribution. Permanent raised beds with full residue retention had a significantly longer time compared to the treatment with complete residue removal. The effect of plant residue removal on soil structure in permanent raised beds was very clear as the MWD decreased with decreasing

Table 2: Turmeric crop yield (t ha^{-1}), input costs (Rs ha^{-1}), and net income (Rs ha^{-1}) under different tillage and crop establishment methods.

Treatment	Crop yield (t ha^{-1})	Crop establishment	Seed cost	Irrigation cost	Fertilizer cost	Herbicide cost	Net income
PRB wide + RI	14.3	1875	48,000	1590	4,150	1250	1,57,635
PRB wide + FRR	16.7	1225	48,000	1500	4,150	600	1,95,025
PRB wide + PRR	11.4	1415	48,000	1675	4,150	750	1,72,010
PRB wide + RR	10.1	1575	48,000	1750	4,150	1250	1,45,275
PRB narrow + RI	9.6	1975	48,000	1725	4,150	1250	1,34,900
PRB narrow + FRR	10.5	1345	48,000	1650	4,150	600	1,54,255
PRB narrow + PRR	8.2	1475	48,000	1815	4,150	750	1,48,810
PRB narrow + RR	7.7	1625	48,000	2120	4,150	1250	1,35,355
Flat beds + RI	4.8	2125	60,000	1950	4,150	1250	75,175
Flat beds + FRR	5.7	1530	60,000	1875	4,150	600	1,02,195
Flat beds + PRR	3.3	1640	60,000	2050	4,150	750	30,410
Flat beds + RR	2.6	2375	60,000	2135	4,150	1250	8,090
C D at 5%	0.87	56.37	37.84	28.65	-	14.56	-

PRB wide + RI = Permanent wide raised beds with residue incorporated; PRB wide + FRR = Permanent wide raised beds with full residue retain; PRB wide + PRR = Permanent wide raised beds with partial residue retain; PRB wide +RR = Permanent wide raised beds with residue removed; PRB narrow + RI = Permanent narrow raised beds with residue incorporated; PRB narrow + FRR = Permanent narrow raised beds with full residue retain; PRB narrow + PRR = Permanent narrow raised beds with partial residue retain; PRB narrow +RR = Permanent narrow raised beds with residue removed; Flat beds + RI = Flat beds with residue incorporated;Flat beds +FRR = Flat beds with full residue retain;Flat beds +PRR = Flat beds with partial residue retain;Flat beds +RR = Flat beds with residue removed.

Table 3: Productivity of turmeric crop under various tillage and crop establishment techniques

Crop establishment	Crop yield (t/ha)		
	2008-09	2009-10	2010-11
PRB wide + RI	11.5	14.7	16.7
PRB wide + FRR	14.6	16.8	18.7
PRB wide + PRR	9.7	11.3	13.3
PRB wide + RR	8.6	9.8	11.9
PRB narrow + RI	8.2	9.4	11.2
PRB narrow + FRR	9.3	10.8	11.4
PRB narrow + PRR	7.6	8.1	8.9
PRB narrow + RR	6.3	7.4	9.4
Flat beds + RI	3.2	4.9	6.3
Flat beds + FRR	4.8	5.6	6.7
Flat beds + PRR	2.9	3.2	3.8
Flat beds + RR	1.9	2.4	3.5
C D at 5%	0.93	1.08	1.23

amounts of residues retained. Aggregate breakdown is a good measure for soil erodibility,as breakdown to finer, more transportable particles and microaggregates, increases erosion risk (Le Bissonais 2003). Conventionally tilled raised beds and permanent raised beds without residue cover present as such a high erosion risk.Similar results were found for infiltration rates on top of the raised bed and in the furrow. Infiltration rates in the bottom of the furrow were significantly higher for conventionally tilled compared to permanent raised beds, but not on top of the raised beds. A lower aggregation results in a reduction of the infiltration and storage capacity of the soil by forming a relatively impermeable soil layer by sealing of pores (Le Bissonais 2003). This corresponded with the higher time to confirm the results found in permanent raised beds with residue retention compared to permanent raised beds with residue removal.The furrows in permanent raised beds are more compacted as all traffic is always concentrated in the furrows. However, in order to take advantage of the active water harvesting system by installing furrows and ridges it is probably more desirable to have slow infiltration rates in the furrow in order to let the water slowly infiltrate to the plant root zone, rather than let it escape to deeper layers due to cracks in the soil. However, ridges will help to actively keep water in the field, which otherwise would be lost as run off, and can compensate for the partial removal of residue.There is a need for further investigations concerning the critical threshold amounts of residue required for maintaining soil productivity. At initial time bulk density of surface layers remains lower under residue retained bed planting than under conventional tillage. This is because top of beds remains loose. The lower bulk density means more porosity especially in upper surface. The cone index was increased significantly under all the tillage and crop establishment techniques but the extent of increase was more under conventional tillage systems.With the passage of time the differences between soil physical parameters get narrowed (Aggarwal and Goswami 2003 ; Limon and Sayre 2002) because height of bed gets reduced and become compacted. As a result of better physical environment (loose soil) under bed planting, higher root length density in upper 0-50 cm soil layer was observed than that of CT system, which was reflected in yield improvement. The adoption of permanent beds will led to controlled traffic thereby providing a healthy root environment. Fine tilth and better aeration causing less penetration resistance are responsible for better root development thereby producing higher yield attributes. Higher yield recorded in ridge planting can be attributed to better soil environment in ridges since prolonged ponding reduces yield (Tisdall and Hodgson,1990).

Table4: Water application and water productivity in turmeric with various tillage and crop establishment techniques.

Crop establishment	Irrigation water applied(mm ha^{-1})			RE means	Water productivity (kg yield m^{-3})			RE means
	2008-09	2009-10	2010-11		2008-09	2009-10	2010-11	
PRB wide + RI	455	515	475	481.7	2.527	2.854	3.516	2.966
PRB wide + FRR	415	470	435	440.0	3.518	3.574	4.299	3.797
PRB wide + PRR	430	485	450	455.0	2.256	2.330	2.956	2.514
PRB wide + RR	475	495	490	486.7	1.811	1.980	2.429	2.073
PRB narrow + RI	495	555	515	521.7	1.657	1.694	2.175	1.842
PRB narrow + FRR	450	510	475	478.3	2.067	2.118	2.400	2.195
PRB narrow + PRR	470	530	490	496.7	1.617	1.528	1.816	1.654
PRB narrow + RR	510	570	530	536.7	1.235	1.298	1.774	1.436
Flat beds + RI	560	620	575	585.0	0.571	0.790	1.096	0.819
Flat beds + FRR	505	570	535	536.7	0.950	0.982	1.252	1.061
Flat beds + PRR	525	595	550	556.7	0.552	0.538	0.691	0.594
Flat beds + RR	575	695	595	621.7	0.330	0.345	0.588	0.421

Table5: Productivity and profitability of Turmeric crop under various residue and establishment techniques.

Crop establishment	Crop Yield (t ha^{-1})	B:C ratio	MWD	Infiltration rate(mm hr^{-1})	Cone Index	Bulk density (Mg m^{-3})
T_1 Wide Beds Planting						
RI-Residue incorporated	14.3	2.77	0.43	83.5	2.40	1.53
FRR- Full residue retain	16.7	3.52	0.47	80.9	2.43	1.51
PRR-Partial residue retain	11.4	3.07	0.42	82.3	2.45	1.52
RR- Residue removed	10.1	2.56	0.39	84.7	2.48	1.54
T_2 Narrow Beds Planting						
RI-Residue incorporated	9.6	2.36	0.41	80.1	2.54	1.53
FRR- Full residue retain	10.5	2.77	0.44	79.8	2.59	1.52
PRR-Partial residue retain	8.2	2.65	0.41	81.2	2.61	1.54
RR- Residue removed	7.7	2.37	0.37	82.4	2.65	1.56
T_3 Flat Beds Planting						
RI-Residue incorporated	4.8	1.08	0.27	54.6	2.82	1.63
FRR- Full residue retain	5.7	1.50	0.29	55.7	2.83	1.62
PRR-Partial residue retain	3.3	0.44	0.21	53.4	2.84	1.64
RR- Residue removed	2.6	0.12	0.23	51.3	2.86	1.66
Initial	-	-	0.32	-	2.25	1.52
C D at 5%	0.87	-	0.08	8.64	0.16	0.07

सारांश

3 वर्षों के लिए सरदार बल्लभभाई पटेल कृषि एवं प्रोद्यौगिक विश्वविद्यालय, मेरठ, उत्तर प्रदेश के प्रक्षेत्र प्रयोग उच्तम उत्पादकता, उपयोगिता एवं संसाधन संरक्षण के लिए हल्दी फसल के साथ पौध विविधिताकरण किया गया। तीन वर्षा के प्रयोग के आधार पर यह निष्कर्ष था कि हल्दी की पौध रोपण के साथ पौध की बाकी की धारणी क्षमता आंशिक–शुष्क उच्च ज्वालामुखी भूमि के लिए वैकल्पिक उत्पादन संभवतः हो सकता है। विस्तृत जुताई के सथ इसके उच्च सम्बन्धी मूल्य को स्थायी पौध रोपण की उपयोगिता कम कर सकते हैं। शायद इसकी श्रेष्ठ रूचि अत्यधिक महत्वपूर्ण है कि दोनो फसलो के लिए आंशिक अवशिष्ट धारणी क्षमता के साथ स्थायी पौध रोपण उपज के साथ पूर्ण धारणी क्षमता समरूप ही प्रदान करता। चूंकि अधिकतम वर्षा आधारित क्षेत्र में चारा ही अवशिष्ट उपयोग के लिए तीव्र प्रतियोगिता है विशिष्टत लघु एवं मध्यम किसान के लिए साहस बढ़ाने की बात होगी यदि 50 प्रतिशत और 70 प्रतिशत के बीज के साथ भूमि की धारण करने की क्षमता को बढ़ा दे। स्थायी पौध रोपण शैया बिना अवशिष्ट धारणी क्षमता के यद्यपि निम्न पौध क्षमता और भूमि वातावरणीय हानि की अगुवाई अकार्वनिक प्रयोग द्वारा है।

References

Aggarwal P and Goswami B (2003) Bed planting system for increasing water use efficiency of wheat grown on Inceptisol (Typic Ustochrept). Indian J. Agral Sci. 73 (8): 422-25.

Aquino P (1998) The adoption of bed planting of wheat in the Yaqui Valley, Sonora, Mexico. 17a. Mexico DF,CIMMYT. Wheat Special Report

Blake GR and Hartge KH (1996). Bulk density. In: Methods of Soil Analysis. Part I.Agronomy (Ed., Klute, A.), pp. 363-375. ASA-SSSA, Madison, WI.

Govaerts B, Sayre KD, Deckers J (2005) Stable high yields with zero tillage and permanent bed planting? Field Crop Res 94:33–42

Le Bissonnais Y (2003) Aggregate breakdown mechanisms and erodibility. In: Lal R (ed) Encyclopedia of soil science. Marcel Dekker Inc., New York

Limon-Ortega A, Sayre KD (2002) Potential for a furrow irrigated, permanent bed planting technology to reduce tillage, augment crop residue retention and improve long-term sustainability for irrigated wheat production systems. Ministry of Agriculture and Water Resources, Tashkent Institute of Irrigation and Agricultural Mechanization Engineers, Tashkent,

Moreno O, Salazar M, Tamayo M, Martý´nez J (1993) Tecnologý´a parala produccio´n de trigo en surcos. Foll. Te´cn. 22. SARH, INIFAP, Cd. Obrego´ n, Sonora, Me´xico.

Naresh, RK, Singh, B. Kumar Ashok Shahi UP, Singh Adesh and Satya Prakash (2010) Diversifying the intensive cereal cropping systems of the Indo-Gangetic Plains through horticulture. Ann. Horti.3 (1): 1-11.

Naresh,R.K.;Singh,B.;Bansal, Sangita; Malik,Sunil; Rathi R.C.; and Singh, K.V.;2010. Raised bed controlled traffic farming for sustainability of vegetable crop production for improving livelihood of Western Indo-Gangetic Plains farmers. Zonal Seminar on Physiological and Molecular interventions for yield and quality improvement in crop plants.Sardar Vallabhbhai Patel University of Ag.& Tech.,Meerut (U.P.):102-115.

Prasad, R. (1998). A Practical Manual for Soil Fertility. Division of Agronomy, Indian Agricultural Research Institute, New Delhi.

Sayre KD (2004) Raised-bed cultivation. In: Lal R (ed) Encyclopedia of soil science. Marcel Dekker, Inc.

Tisdall, JM and AS Hodgson.1990. Ridge tillage in Australia: a review. Soil and Tillage Res. 18: 127-44.