



Effect of Tillage and Nutrient Management on Economics and Soil Status by Maize + Pigeon Pea Intercropping System

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Abstract

A field experiment was carried out during the summer (kharif) seasons of 2019-20 at research farm field in TCA, Dholi, under Dr. RPCAU, Pusa, Samastipur (Bihar). The experiment was laid out in split plot design with 4 main plot treatment viz., T 1: Permanent bed (PB), T 2: Zero tillage (ZT), T 3: Fresh bed (FB) and T 4: Conventional tillage and 3 sub-plot treatment viz., N 1: 100% Recommended dose of fertilizer (RDF), N 2: 120% Recommended dose of fertilizer (RDF) and N 3: 80% Recommended dose of fertilizer (RDF) which were replicated thrice. Considering the overall impact of conservation agriculture practices, growing maize+pigeon pea intercropping under PB, crop recorded higher maize equivalent yield (130.7 q/ha) at par with ZT (120.7 q/ha) over the FB (112.1 q/ha) and CT (108.4 q/ha) while, 120% RDF application recorded (127.7 q/ha) over the 100% RDF (117.7 q/ha) and 80% RDF (108.6 q/ha) application under nutrient management. The gross return, net return and B:C ratio from maize+pigeon pea intercropping obtained significantly higher under PB (244839, 189239 and 3.4) compared to FB (210514, 153665 and 2.7) and CT (203320, 147070 and 2.6) while under nutrient management, the gross return, net return and B:C ratio recorded higher with 120% RDF application (239028, 181223 and 3.1) compared to 80% RDF (204076, 150031 and 2.8). The soil physico-chemical properties viz., bulk density, pH, EC, organic carbon, available N, P and K were also favourably influenced by PB and ZT practices but it's were not significantly affected by nutrient management practices. Appropriate tillage practices and nutrient management are some of the reasons behind the increasing economics or net returns of crop. Therefore, the study was conducted to identify the appropriate tillage practices and suitable nutrient management in new immersing maize + pigeonpea intercropping system in an alternative conventional farming.

Keywords: Tillage; Nutrient Management; Economics; Soil Status; Maize + Pigeon Pea

Introduction

Agricultural systems are already affected by several challenges while climate variability and climate change are accentuating further these negative impacts on food production McKersie, 2015 [14]. In changing climate, we adopt the crops, variety and production technology that suitable in this climate, like altering in planting pattern and intercropping practices. In India after green revolution continuous cereal-cereal based production systems coupled with

conventional cultivation practices has led to numerous production vulnerabilities Paul, et al. 2014 [21]. Thus, in order to sustain the soil and crop productivity, the minimum soil disturbance, organic soil cover and crop diversification assume great importance Gangwar, et al. 2006 [4]. Crop diversification through intervention of legumes as well as integrated crop, soil, nutrient and pest management are some of the viable options to cope up the emerging challenges in Indian agriculture. In this study we conduct a field experi-

ment on maize + pigeonpea (2:2) intercropping on different tillage and nutrient management practices. Maize crop has highest yield potential among the all cereals crop that increase the net benefit of farmer. Although, our honourable prime minister also says the doubling the farmer income up to 2022. So, the main aim of this experiment to doubling the small farmer income through maize + pigeon pea intercropping system. Because under Bihar condition the traditional pigeon pea grown as long duration crop that gain the lower net income. As well as cereal + legume intercropping sustains the soil health and other physicochemical property of soil. Maize and pigeon pea production can be improved by using better inputs, proper production technology and by proper tillage practices that reduce the cost of cultivations. Tillage contributes in yield up to 20% among all the crop production factors Ahmad, *et al.* 1996 [16]. Use of intensive and unnecessary conventional tillage practices is often harmful to soil and also increase the cost of cultivation. Therefore, currently there is a significant interest and emphasis on the shift to the permanent bed and zero-tillage for increasing the net economic benefit to farmer and without affect the natural resources maintain the soil health and controlling erosion process and increasing crop production Dawelbeit and Babiker, 1997 [12].

Appropriate tillage practices and nutrient management are some of the reasons behind the increasing economics or net returns of crop and also conservation tillage with nutrient management practices impact on enhancing soil fertility status. Therefore, the study was conducted to identify the appropriate tillage practices and suitable nutrient management in new immersing maize + pigeonpea intercropping system in an alternative conventional farming.

Material and Methods

A field experiment was carried out during the summer (*khariif*) seasons of 2019-20 at research farm field in TCA, Dholi, under Dr. RPCAU, Pusa, Samastipur (Bihar). The experiment was executed in split plot design with three replications having net plot size of 8.44m x 4.20m.

The experiment consists of following treatments.

A: Tillage practices (Main plot)

T1 = Zero tillage

T2 = Permanent bed

T3 = Fresh bed

T4 = Conventional tillage.

B: Nutrient management (Sub plots)

N1 = 100% RDF

N2 = 120% RDF

N3 = 80% RDF.

Pigeon pea variety 'Bahar' and Maize 'P3322' were sown in 3rd week of June and maize was harvested in third week of October while the pigeon pea was harvested in second week of April next year of experimentation. Maize and pigeon pea were sown in 2:2 ratio row 67/20 cm apart and plant to plant distance of 20 cm were maintained by thinning at 15 days after sowing. The recommended dose of fertilizers i.e. Maize (120:60:50 NPK Kg/ha) and pigeon pea (30:50:30 NPK Kg/ha) were given individually. Full dose nitrogen, phosphorous and potassium in pigeon pea were applied at the time of sowing according to the treatment in each plot. However, in maize, half of nitrogen, full dose of phosphorous and potassium were applied at the time of sowing and remaining nitrogen was top dressed in two equal splits i.e. 1/4th at knee-high and 1/4th at tasseling stage of the crop according to the treatment in each plot. One hand weeding was done at 30 day of sowing. The initial and final pH, EC, bulk density, organic carbon, N, P and K content of soil were analysed as per standard methods. For comparison between treatments, the yields of crops were converted into maize equivalent yield on prevailing market price Tomar and Tiwari, 1990 [34].

Results

Maize equivalent yield

Maize equivalent yield significantly affected by both tillage and nutrient management treatments (Table 1). Under the tillage practices, permanent bed gave the highest maize equivalent yield over to fresh bed and conventional tillage treatment. PB recorded significantly higher MEY (130.7 q ha⁻¹) which was at par with the ZT (120.7 q ha⁻¹) followed by FB (112.09 q ha⁻¹) and CT (108.37 q ha⁻¹), respectively. As like, tillage practices, nutrient management was also significantly differed the MEY. 120% RDF treatment recorded significantly high MEY (127.6 q ha⁻¹), which was over the 100% RDF (117.70 q ha⁻¹) and 80% RDF (108.56 q ha⁻¹) nutrient management.

Treatments	MEQ (q/ha)
Tillage practices	
Zero Tillage	120.7
Permanent Bed	130.7
Fresh Bed	112.1
Conventional tillage	108.4
SEm±	2.95
LSD (p =0.05)	10.2
Nutrient management	
100 % RDF	117.7
120% RDF	127.7
80%RDF	108.6
SEm±	2.39
LSD (p = 0.05)	7.2
LSD (p = 0.05) (T×N Interaction)	NS

Table 1: Maize equivalent yield (q/ha) of maize affected by tillage and nutrient management practices.

Gross returns, net returns and B: C ratio

The economic data like Gross returns, net returns and B: C ratio was significant differed by tillage practices (Table 2). Among the tillage practices, the gross returns were significantly superior in PB (244839 ₹/ha) which was statistically over to ZT (226434 ₹/ha),

FB (210514 ₹/ha) and CT (203320 ₹/ha). As well as net returns also significantly higher found in PB (189239 ₹/ha) which was at par with ZT (171434 ₹/ha) and over with FB (153665 ₹/ha) and CT (147070 ₹/ha). Whereas significantly superior B: C ratio was found in PB (3.4) which was statistically at par with ZT (3.1) over FB (2.7) and CT (2.6). Across nutrient management treatments significantly highest gross returns was obtained in 120% RDF (239028 ₹/ha) which was statistically over 100% RDF (220727 ₹/ha) and 80% RDF (204076 ₹/ha). Similarly, higher net returns were found in 120% RDF (181223 ₹/ha) which was statistically over 100% RDF (164802 ₹/ha) and 80% RDF (150031 ₹/ha). The benefit: cost ratio was highest in 120% RDF (3.13) which was at par with 100% RDF (2.9) over the 80% RDF (2.7). Similarly, the cost of cultivation of maize pigeon pea intercropping system varied in tillage and nutrient management practices. Maximum cost of cultivation was found in FB, 120% RDF (58730 ₹/ha) treatment. Whereas, minimum cost of cultivation was found in ZT, 80% RDF (53120₹/ha) treatment.

Soil physico-chemical property

The soil physical properties viz., bulk density was significantly influenced by tillage practices (Table 3). Under tillage practice, bulk density the minimum values were obtained in PB and ZT (1.27 and 1.28 g cm⁻³) and maximum was recorded in CT and FB (1.35 and 1.32 g cm⁻³).

Treatments	Gross returns (₹/ha)	Net returns (₹/ha)	Benefit: cost ratio
Tillage practices			
Zero Tillage	226434	171434	3.1
Permanent Bed	244839	189239	3.4
Fresh Bed	210514	153665	2.7
Conventional tillage	203320	147070	2.6
SEm±	5040.86	5040.8	0.09
LSD (p =0.05)	17444	17444	0.3
Nutrient management			
100 % RDF	220727	164802	2.9
120% RDF	239028	181223	3.1
80%RDF	204076	150031	2.8
SEm±	4158.4	4158.4	0.07
LSD (p = 0.05)	12466	12467	0.2
LSD (p = 0.05) (T×N Interaction)	NS	NS	NS

Table 2: The economics of maize-pigeon pea intercropping system affected by tillage and nutrient management practices.

Treatments	Bulk density (g cm^{-3})	
	Before sowing	After harvesting
Tillage practices		
Zero Tillage	1.28	1.27
Permanent Bed	1.27	1.25
Fresh Bed	1.32	1.31
Conventional tillage	1.35	1.34
SEM \pm	0.01	0.013
LSD ($p = 0.05$)	0.03	0.04
Nutrient management		
100 % RDF	1.30	1.29
120% RDF	1.31	1.29
80%RDF	1.29	1.28
SEM \pm	0.008	0.01
LSD ($p = 0.05$)	NS	NS
LSD ($p = 0.05$) (T \times N Interaction)	NS	NS

Table 3: Physical property of pre and post-harvest of soil affected by tillage and nutrient management practices.

Nutrient management practices were not affected soil physical properties. The minimum values of bulk density were obtained in 80% RDF (1.29 g cm^{-3}) and maximum was recorded in 120% RDF (1.31 g cm^{-3}).

Post-harvest soil.

In tillage practices, bulk density was significantly observed lower in PB (1.25 g cm^{-3}) whereas maximum bulk density was obtained in CT (1.34 g cm^{-3}). Across the nutrient management treatments, the lower bulk density was recorded in 80% RDF (1.28 g cm^{-3}) and maximum was recorded with 100% or 120% RDF (1.29 g cm^{-3}).

Initial soil chemical properties *viz.*, organic carbon (OC), available phosphorous (P) and potassium (K) were affected by tillage practices (Table 4 and 5). Whereas nutrient management had no significant influence on soil chemical properties. In tillage practices, organic carbon was significantly superior under ZT (0.60%) and statistically at par with PB (0.59%) as compared to FB (0.53%) and CT (0.48%). The available phosphorous in soil was significantly superior in ZT (32.0 kg ha^{-1}) which was at par with PB (32.1 kg ha^{-1}) as related to FB (29.2 kg ha^{-1}) and CT (28.5 kg ha^{-1}). Available potassium was maximum in ZT (127.5 kg ha^{-1}) which

was statistically at par with PB (126.3 kg ha^{-1}) as compared to FB (122.7 kg ha^{-1}) and CT (122.0 kg ha^{-1}). Although available nitrogen in soil showed non-significant but higher nitrogen was recorded in ZT (227.5 kg ha^{-1}) followed by PB (226.2 kg ha^{-1}) and CT (216.9 kg ha^{-1}).

Among the nutrient management practices, the soil chemical properties were not significantly affected. The maximum organic carbon was observed in 120% RDF (0.56%) and minimum values were obtained with 80% RDF treatment (0.54%). Similarly, the available nitrogen was maximum in 120% RDF (223.1 kg ha^{-1}) followed by 100% RDF (222.5 kg ha^{-1}) and 80% RDF (221.1 kg ha^{-1}). Available phosphorous was maximum recorded with 120% (31.1 kg ha^{-1}) followed by 100% RDF (30.9 kg ha^{-1}) and 80% RDF (29.3 kg ha^{-1}). The available potassium was maximum in 120% (126.8 kg ha^{-1}) and minimum was observed in 80% RDF (121.9 kg ha^{-1}).

The final soil chemical status was significantly affected by different tillage and nutrient management treatments (Table 4). Under tillage treatments, ZT and PB (0.62% and 0.62%) showed significantly superior organic carbon as compared to FB (0.54%) and CT (0.050%). The available N and K in soil were significantly superior with PB (270.7 , and 134.5 kg ha^{-1}) which were significantly at par with ZT (269.0 and 133.5 kg ha^{-1}) as compared to FB (257.0 and 129.5 kg ha^{-1}) and CT (255.0 and 126.3 kg ha^{-1}) respectively. Similarly, phosphorous is also maximum found in ZT (33.6 kg ha^{-1}) which was significantly at par with PB (33.5 kg ha^{-1}) and significantly over the FB and CT (30.9 and 30.5 kg ha^{-1}) respectively.

Although nutrient management practices showed no significant differences in soil chemical properties. The higher organic carbon was obtained with 120% RDF (0.58%) treatment followed by 100% RDF (0.57%) and 80% RDF (0.56%) treatment. 120% RDF (268.4 , 32.7 and 131.7 kg ha^{-1}) showed maximum available N, P and K content in soil. Whereas, minimum values of available N, P and K was observed in 80% RDF (257.1 , 31.1 and 129.7 kg ha^{-1}).

Discussion

Maize equivalent yield

The maize equivalent yield was significantly affected due to the tillage practices treatment. PB treatment performed better and at par with the ZT and over the FB and CT. PB treatment was greater than other 8.25, 16.60 and 20.61% over the ZT, FB and CT treatment. This is mainly due to PB performed better in all crop growth

stages and yield attributing characters and also, pigeon pea gave the additional yield advantage and in addition to more economic price of grain pigeon pea. Pigeon pea being a legume, fixes the atmospheric nitrogen and improves the soil fertility. Therefore soil fertility improvement might have brought in more yield so, by registering higher maize equivalent yield. Sepat., *et al.* 2015 [27], Singh., *et al.* 2018 [30] also, found in pigeon pea-wheat system.

In nutrient management treatment significantly affected the maize equivalent yield. 120% RDF treatment and 100% RDF treatment increment the 17.60 and 8.42% yield over the 80% RDF treatment. This was due to all yield character found more in 120% RDF treatment over the other and also nulls effects on yield of maize by intercropping Meena., *et al.* 2009 [15] and Krishnaprabu, 2019 [9]. Pandey., *et al.* 2013 [19] also, collaborated with this result.

Economics

The CA were significantly influenced the economics of maize-pigeon pea intercropping. The higher gross return (244839 ₹/ha), net returns (189239 ₹/ha) and B: C ratio (3.40) were noted in PB, while lowermost values of net returns (147070 ₹/ha) and B: C ratio (2.61) were noted in CT (Table 4). The reason behind higher net returns and B: C ratio under PB was lower production cost and enhanced yields which lead to 28.67 and 30.26% respectively increased in net returns and B: C ratio over CT practice. While, conservation tillage systems use reduced inputs, labour and energy providing potentially more economic benefits Ram., *et al.* 2011 [24]. Singh., *et al.* 2010 [31] found under pigeon pea-wheat cropping system, Pal and Bhatnagar, [18] also noticed similar results. Parihar., *et al.* 2016 [20] observed similar cost of cultivation in permanent bed (PB) under different crops of maize based system. Jat., *et al.* 2012 [6] noticed under minimum tillage significantly more net returns and B:C ratio compared to normal tillage.

In nutrient management level, highest gross return (239028 ₹/ha), net returns (181223 ₹/ha) and monetary advantage index (3.13) was tended to record by 120% RDF treatment that significantly higher compared to 80% RDF treatment was due to lesser cost of cultivation and higher biological yields. Pandey., *et al.* 2013 [19], Kumawat., *et al.* 2013 [10] and Vyas., *et al.* 2006 [35] found the similar results.

Soil physical properties

The conservation tillage practices (*viz.*, PB and ZT) improved bulk density that lead to increase soil health. However, BD showed

significant difference among the treatment, minimum values of BD was found in PB and ZT which indicates that the textural properties requires more time for change. The lower value of BD was due to continues addition of organic matter as crop residue leads to increase microbial population, water holding capacity. In addition, pigeon pea-based intercropping lower bulk density of the soil might be due to addition of sufficient quantity of plant leaf and stubble and their decomposition, in conservation tillage practices there will be lesser trafficking through tractor and machineries which helps to restrict soil compaction in sub layers and leads to infiltrate more amount water in soil profile. Yang and Wander, 1999 [37] reported lower BD was observed in conservation agriculture practices (CA). Similar results were also reported by Salem., *et al.* 2015 [26]. Pandey., *et al.* 2013 [19] found decrease the BD due to pigeon pea-based intercropping.

However, nutrient management practices were not significantly manipulated bulk density by the. But nutrients have some extra effects on soil physical properties. In this context, augmented supply of nutrients increases the soil microbial population which helps to improve bulk density and soil penetration resistance and ultimately improves soil physical properties. These results were in conformity with the findings of Nandapure., *et al.* 2011 [17]. In contracts to these some workers also reported lower improvement of soil physical properties under 100% RDF Sinha., *et al.* 2013 [33]. Salahin., *et al.* 2011 [25] reported 100% RDF and same doses of N supply from cow dung did not affect the BD.

Soil chemical properties

The soil chemical properties of a fixed site were significantly influenced by CA practices. Higher organic carbon, available N, P, and K were observed with conservation tillage practices (ZT and PB). More amount of these nutrients in soil may be due application of surface retention of residues, leaf litter fall of pigeon pea, more favorable effect of PB and ZT on root and nodules development of pigeon pea and intact remains of roots in the rhizosphere which helps to release the nutrients in soil through decomposition. In addition to this, application of organic matter to the soil supports to slowly release of nutrients and make available throughout the growing season of the succeeding crop. Further, increased organic carbon in PB and ZT helps to form organic chelates with the nutrients and reduces the loss of applied fertilizers. But, in case of CT the applied nutrients may leach to deeper soil layers, regular tillage enhanced the rate of organic matter decomposition and harm the soil fertility as well as structural stability. The developed SOC in conservation tillage practices compared to FB and CT might be due

to more root proliferation and leaf biomass of pigeon pea. Finally, enhanced soil organic carbon, NPK status helps to improve soil health and ultimately lead to enhanced growth and development plant Phiri., *et al.* 2013 [22]. Singh., *et al.* 2009 [29] reported that the fungi present in rhizosphere of mungbean produces a glyco-protein called glomalin which helps to entrap the nutrients present in soil. Lauren., *et al.* 2008 [11] and He., *et al.* 2011 [5] also observed increment of soil nutrients under conservation agriculture practices. The improvement of nitrogen status under CA practices was reported by Wang., *et al.* 2008 [36] and Singh., *et al.* 2014 [32]. The above findings were collaborated with Betrol., *et al.* 2007 [1], Malhi., *et al.* 2011 [13] and Du Preez., *et al.* 2001 [3]. Higher NPK status was also observed in conservation agriculture practices by Kahlon and Singh, 2014 [7] and Kaiser., *et al.* 2014 [8] described improvement in soil organic carbon with adoption of CA practices.

Under nutrient management practices, 120% RDF and 100% RDF treatments improved soil chemical property like organic carbon and NPK status. Increase in concentration of nutrients is due to application of sufficient amount of nutrient which helps to release nutrients in to the soil by mineralization. The higher soil organic carbon and NPK status was improved with 120% RDF treatments Singh., *et al.* 2014 [32]. Chesti., *et al.* 2013 [2] found same result at 100% RDF over INM. and Sepehya., *et al.* 2012 [28] also supported with 100% RDF similar findings.

Conclusion

The maize equivalent yield was superior under PB and ZT compared to FB and CT practices and as well as same found under nutrient management practices 120% RDF found maximum MEQ compared to 100% and 80% RDF treatment. The MEQ value affected the economics of intercropping system so that maximum economic benefit found under PB and ZT practices compared to CT and 120% RDF over to 100% and 80% RDF. The physico-chemical property superior under PB and ZT compared to CT practices.

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