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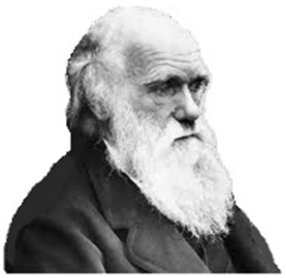

World News of Natural Sciences

An International Scientific Journal

WNOFNS 24 (2019) 71-78 EISSN 2543-5426

Economic analysis of maize hybrid influenced by tillage method and planting density

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ABSTRACT

The experiment was laid out in a strip-split plot design consisting of 16 treatments with three replications, at NMRP, Rampur, Chitwan, Nepal, during the winter season (October, 2015 to March, 2016). Four different levels of planting geometry (60 cm×30 cm, 60 cm×24 cm, 60 cm×19.5 cm, and 60 cm×16.5 cm, representing 55,555, 69,444, 85,470 and 1,01,010 plants ha^{-1}, respectively), two hybrid varieties of maize (Rampur hybrid 4 and Rampur hybrid 6), and two tillage methods (conventional and zero tillage), were used for the treatments. Economic analysis revealed that significantly higher net benefit (NRs. 1,06,692 ha^{-1}) was obtained with 85 rather than 55 thousand plants ha^{-1} (NRs. 79,249 ha^{-1}), but remained at par with 69 (NRs. 92,656 ha^{-1}) and 101 (NRs. 96,198 ha^{-1}) thousand plants ha^{-1}. Moreover, the B:C ratio was higher in 85 (2.57) than 55 (2.28), 69 (2.43), and 101 (2.35) thousand plants ha^{-1}. The net returns and B:C ratio (NRs. 97,372 and 2.46) obtained from Rampur hybrid 6 were also higher, but statistically at par with Rampur hybrid 4 (NRs. 90,024 and 2.35), respectively. In addition, net returns and B:C ratio obtained from zero tillage (NRs. 1,03,473 and 2.6) were better than conventional tillage (NRs. 83,924 and 2.22). Thus, both hybrid maize varieties (Rampur hybrid 4 and Rampur hybrid 6) can be successfully grown under a zero tillage system with an optimum plant population of 85 thousand plants ha^{-1} to achieve a higher grain yield and better winter season net returns in western Chitwan, Rampur, Nepal.

***Keywords*:** Maize, B:C ratio, Economic analysis, planting density, tillage method, *Zea mays*

(Received 08 March 2019; Accepted 21 March 2019; Date of Publication 22 March 2019)

1. INTRODUCTION

Maize is the most important cereal crop in the world after wheat and rice. It's rank second position after rice in term of area and production in Nepal [1-2]. At present, the maize sown area in Nepal is 882,395 ha, with a total production of 2,145,291 metric tons and productivity of 2.43 ton ha^{-1}. It is a principal food crop of the hilly farmers and source of animal feed for different feed industries in Terai region of Nepal [3]. In the hills of Nepal, more than 86% maize production has been used for human consumption and 80% maize production in the Terai is used for poultry and animal feed. Productivity of maize is very low, i.e. 2.43 ton ha^{-1} as compared to USA, China and Brazil (10.73, 5.81, and 5.40 metric ton ha^{-1}, respectively). Among different factors, hybrids, tillage and plant population can be considered as important factors which can contribute to improve grain yield of maize in our condition [4]. Further, the cost of crop production is becoming higher due to higher cost of inputs and labour in Nepal. Therefore, it is also essential to evaluate the performance of hybrid maize varieties under different tillage practices. Tillage represents half of the operations carried out annually in the field. Consequently, there is a potential to reduce energy inputs and production costs by reducing tillage [5]. Hence, zero and minimum tillage may be introduced to offset the production cost and other constraints associated with environment and socio-economic conditions [6]. So, people are now giving more emphasis to adopt zero tillage practice [7-8].

Sharifi *et al*. [9] also mentioned that maize hybrids differ in their response to plant density. Also, appropriate plant spacing gives the right plant density, which is the number of plants, allowed on a given unit of land for optimum yield [10]. Thus, plant spacing is an important agronomic input parameter since it is believed to have effects on light interception during which photosynthesis takes place, which is the energy manufacturing medium using green parts of the plant [11-17]. This research aims to analyze economics of the hybrid maize production in different tillage and planting density.

2. MATERIALS AND METHODS

2. 1. Experimental site

A field experiment was conducted during winter season (October, 2015 to March, 2016) at the research farm of National Maize Research Program (NMRP), Rampur, Chitwan, Nepal. The experimental site is 10 km far towards south–west direction from headquarter of Chitwan district, Bharatpur. It is located at 27º37' North latitude and 84º25' East longitude with an elevation of 256 meter above mean sea level. Geographically, the experimental location falls in the inner terai region of central development region of Nepal.

2. 2. Experimental details

The experiment was laid out in a strip-split plot design consisting of 16 treatments with three replications. Four different levels of planting geometry (60 cm × 30 cm, 60 cm × 24 cm, 60 cm × 19.5 cm, and 60 cm × 16.5 cm, representing 55,555, 69,444, 85,470 and 101,010 plants ha^{-1}, respectively), two hybrid varieties of maize (Rampur hybrid 4, and Rampur hybrid 6) and two tillage methods (conventional and zero tillage) were used as the treatments. The recommended dose of fertilizers used in the experiment was 120:60:40 kg N:P_2O_5:K_2O per hectare. All intercultural operations, like thinning, plant protection, weed management, irrigation were followed as per National Maize Research Program (NMRP) recommendation.

All taken data were entered into MS EXCELL and analysis of data by using statistical Package R.

2. 3. Treatment details

Treatment	Notation	Treatment combination
T1	ZTV1D1	Zero tillage for Rampur hybrid 4 with 55,555 plants ha^{-1}
T2	ZTV1D2	Zero tillage for Rampur hybrid 4 with 69,444 plants ha^{-1}
T3	ZTV1D3	Zero tillage for Rampur hybrid 4 with 85,470 plants ha^{-1}
T4	ZTV1D4	Zero tillage for Rampur hybrid 4 with 1,01,010 plants ha^{-1}
T5	ZTV2D1	Zero tillage for Rampur hybrid 6 with 55,555 plants ha^{-1}
T6	ZTV2D2	Zero tillage for Rampur hybrid 6 with 69,444 plants ha^{-1}
T7	ZTV2D3	Zero tillage for Rampur hybrid 6 with 85,470 plants ha^{-1}
T8	ZTV2D4	Zero tillage for Rampur hybrid 6 with 1,01,010 plants ha^{-1}
T9	CTV1D1	Conventional tillage for Rampur hybrid 4 with 55,555 plants ha^{-1}
T10	CTV1D2	Conventional tillage for Rampur hybrid 4 with 69,444 plants ha^{-1}
T11	CTV1D3	Conventional tillage for Rampur hybrid 4 with 85,470 plants ha^{-1}
T12	CTV1D4	Conventional tillage for Rampur hybrid 4 with 1,01,010 plants ha^{-1}
T13	CTV2D1	Conventional tillage for Rampur hybrid 6 with 55,555 plants ha^{-1}
T14	CTV2D2	Conventional tillage for Rampur hybrid 6 with 69,444 plants ha^{-1}
T15	CTV2D3	Conventional tillage for Rampur hybrid 6 with 85,470 plants ha^{-1}
T16	CTV2D4	Conventional tillage for Rampur hybrid 6 with 1,01,010 plants ha^{-1}

3. RESULT

3. 1. Economic analysis

3. 1. 1. Cost of cultivation

Cost of cultivation is the total expenditure incurred for raising crops [11]. The cost of cultivation was calculated on the basis of local market price for different agro inputs, viz. seed, labour, fertilizer, compost, machinery, and other necessary materials. Finally, these individual costs of maize cultivation were added to obtain the cost of cultivation. For both hybrids, the cost of production was NRs. 66,547.8 ha^{-1}.

The difference in production cost with respect to tillage methods was not significant, however, it was remarkably higher in conventional tillage (NRs. 68,522.8 ha^{-1}) as compared to zero tillage (NRs. 64,572.8 ha^{-1}).

With respect to plant population, remarkably higher production cost (NRs. 71,147.8 ha^{-1}) was recorded in 101 thousand plants ha^{-1} than other population 55 (NRs. 61,997.8 ha^{-1}), 69 (NRs. 65,047.8 ha^{-1}) and 85 (NRs. 67,997.8 ha^{-1}) thousand plants ha^{-1}, respectively.

3. 1. 2. Gross income

The total monetary value of the economic produce and by-products obtained from the crop and calculated on the basis of the local market price is called the gross return. The mean gross returns of the experiment was NRs. 1,60,246 ha^{-1} ranging from NRs. 1,41,246 ha^{-1} to NRs. 1,74,690 ha^{-1}. The maize hybrids did not differ significantly with respect to gross return, however, it was higher in Rampur hybrid 6 (NRs. 1,63,920 ha^{-1}) than Rampur hybrid 4 (NRs. 1,56,572 ha^{-1}). Similarly, the tillage methods did not differ significantly with respect to gross income, however, it was higher in zero tillage (NRs. 1,68,046 ha^{-1}) than that of conventional tillage (NRs. 1,52,447 ha^{-1}).

Further, with respect to plant population, significantly higher gross returns was obtained with 85 (NRs. 1,74,690 ha^{-1}) than 55 (NRs. 1,41,246 ha^{-1}) and 69 (NRs. 1,57,704 ha^{-1}) thousand plants ha^{-1} but remained at par with 101 (NRs. 1,67,345 ha^{-1}) thousand plants ha^{-1} which was also non-significantly different than 69,444 plants ha^{-1}. However, the gross income recorded in 55 and 69 thousand plants ha^{-1} were significantly different with each other.

Table 2. Total cost of production, gross returns, net returns and B:C ratio of maize hybrids as influenced by tillage methods and plant population during winter season at NMRP, Rampur, Chitwan, Nepal, 2015/16

Treatments	Total cost (NRs. ha^{-1})	Gross returns (NRs. ha^{-1})	Net returns (NRs. ha^{-1})	B:C ratio
Varieties				
Rampur hybrid 4	66,547.8	1,56,572	90,024	2.35
Rampur hybrid 6	66,547.8	1,63,920	97,372	2.46
LSD (=0.05)		ns	ns	ns

SEm (±)		5526.7	5526.7	0.08
Tillage methods				
ZT	64,572.8	1,68,046	1,03,473	2.60
CT	68,522.8	1,52,447	83,924	2.22
LSD (=0.05)		ns	ns	ns
SEm (±)		8354.7	8354.7	0.12
Plant population (ha^{-1})				
55,555	61,997.8	1,41,246^{c}	79,249^{b}	2.28
69,444	65,047.8	1,57,704^{b}	92,656^{ab}	2.43
85,470	67,997.8	1,74,690^{a}	1,06,692^{a}	2.57
1,01,010	71,147.8	1,67,345^{ab}	96,198^{a}	2.35
LSD (=0.05)		15079.7	15079.7	ns
SEm (±)		5166.4	5166.4	0.07
CV, %		11.2	19.1	11.3
Grand mean	66547.8	160246	93698	2.41

Means followed by the common letter(s) within each column are not significantly different at 5 % level of significance by DMRT; ns = non-significant; B:C ratio Benefit cost ratio

3. 1. 3. Net returns

The mean net returns of the experiment was NRs. 93,698 ha^{-1} and it ranged from NRs. 79,249 to NRs. 1,06,692 ha^{-1}. The maize hybrid varieties did not differ significantly in respect of net returns however, Rampur hybrid 6 (NRs. 97,372 ha^{-1}) exceeded to Rampur hybrid 4 (NRs. 90,024 ha^{-1}).

With respect to tillage methods, non-significantly higher net returns were achieved in zero tillage (NRs. 1,03,473 ha^{-1}) as compared to conventional tillage (NRs. 83,924 ha^{-1}).

Economic analysis revealed that significantly higher net benefit was obtained with 85 (NRs. 1,06,692 ha^{-1}) as compared to 55,555 (NRs. 79,249 ha^{-1}) thousand plants ha^{-1} however, it was at par with 69 (NRs. 92,656 ha^{-1}) and 101 (NRs. 96,198 ha^{-1}) thousand plants ha^{-1} which were also similar to each other.

3. 1. 4. Benefit cost ratio

The average B:C ratio in maize production was 2.41 (**Table 2**) and ranged from 2.22 to 2.60 depending upon the treatments. The hybrids did not differ significantly with respect to

benefit cost ratio. However, hybrid Rampur hybrid 6 (2.46) gave higher benefit cost ratio as compared to Rampur hybrid 4 (2.35).

Similarly, tillage method also did not differ significantly in respect of B:C ratio. Non significantly higher B:C ratio (2.60) was obtained in zero tillage as compared to conventional tillage (2.22). Further, with respect to plant population, non-significantly higher B:C ratio was obtained with 85 (2.57) than 55 (2.28), 69 (2.43) and 101 (2.35) thousand plants ha^{-1}.

4. DISCUSSION

4. 1. Economic analysis

Cultivation cost of the experiment was found to be same for both hybrids (NRs. 66,547.8 ha^{-1}) since, the seed cost (NRs. 100 kg^{-1}) was the same for both hybrids (Rampur hybrid 6 and Rampur hybrid 4). Sharma (2015) also reported similar cost for two hybrids (RML 32/RML 17 and Rampur hybrid 2), i.e. NRs. 71,929.67 ha^{-1} in the summer planted maize in Chitwan. On the other hand, the cost of production was higher in conventional tillage (NRs. 68,522.8 ha^{-1}) than zero tillage (NRs. 64,572.8 ha^{-1}) since the cost of first ploughing, second harrowing and field levelling were applied in conventional tillage where zero tillage avoid all these practices. The result was also supported by the finding where the conventional tillage cost was higher (NRs. 75,204.67 ha^{-1}) than zero tillage (NRs. 68,654.67 ha^{-1}) in the condition of Chitwan. Similarly, with the increase in plant population, the cost of production was also increased remarkably from 55 (NRs. 61,997.8 ha^{-1}) to 101 (NRs. 71,147.8 ha^{-1}) thousand plants ha^{-1} which was due to the higher dose of seed material, labour cost during sowing, harvesting and shelling operations in higher population than lower.

Non-significantly higher net returns (NRs. 97,372 ha^{-1}) was obtained from Rampur hybrid 6 than Rampur hybrid 4 (NRs. 90,024 ha^{-1}) in this experiment which was related to remarkably higher grain yield of Rampur hybrid 6 (6.11 t ha^{-1}) as compared to Rampur hybrid 4 (5.88 t ha^{-1}). Similar result was obtained where non-significantly higher net returns were recorded in Rampur hybrid 2 (NRs. 52,474.62 ha^{-1}) than RML 32/RML 17 (NRs. 51,862.87 ha^{-1}) in summer planted maize in Chitwan. Similarly, Karki *et al*. [4] also obtained non-significantly higher net returns in Rampur hybrid 2 (NRs. 32,452.64 ha^{-1}) than RML 32/RML 17 (NRs. 27,722.12 ha^{-1}) in spring planted maize in Chitwan.

On the other hand, zero tillage gave remarkably higher net returns (NRs. 1,03,473 ha^{-1}) than conventional tillage (NRs. 83,924 ha^{-1}) which was also related with grain yield which was higher in zero tillage (6.25 t ha^{-1}) but non-significantly different from conventional (5.74 t ha^{-1}). Similar was the finding who obtained non-significantly higher net returns in zero tillage (NRs. 57,015.84 ha^{-1}) than conventional tillage (NRs. 47,321.66 ha^{-1}) in summer planted maize in Chitwan. Similarly, Karki *et al*. [4] also found remarkably higher net returns in zero tillage (NRs. 36,270.77 ha^{-1}) than conventional tillage (NRs. 23,903.98 ha^{-1}) but the difference was not significant in spring season of 2014 in Chitwan.

The net returns was found to increase from 55 (NRs. 79,249 ha^{-1}) to 85 (1,06,692 ha^{-1}) thousand plants ha^{-} ha^{-1} and then declined at higher population of 101 thousand plants ha^{-1} (NRs. 96,198 ha^{-1}). The net returns obtained in 85 and 101 thousand plants ha^{-1} were similar to each other but significantly greater than 55 thousand plants ha^{-1}. Moreover, the net returns obtained from 69 thousand plants ha^{-1} (NRs. 92,656 ha^{-1}) were similar to all populations. Similar result was also obtained by Karki *et al*. [4].

The treatment with higher population (66 thousand plants ha^{-1}) gave non-significantly higher net returns (NRs. 51,032 ha^{-1}) than 57 (NRs. 19,045.18 ha^{-1}) and 53 (NRs. 20,184 ha^{-1}) in spring season in Rampur, Chitwan.

Further, the B:C ratio obtained in this experiment was non-significantly higher in Rampur hybrid 6 (2.46) than Rampur hybrid 4 (2.35) which was due to the higher gross returns obtained from Rampur hybrid 6 than Rampur hybrid 4 (Table 2) owing to remarkable difference in grain yield. Sharma [12] also reported non-significant difference in B:C ratio with respect to hybrids RML 32/RML 17 (1.02) and Rampur hybrid 2 (1.03) in the summer season of 2014 in Chitwan. Karki *et al*. (2015) also recorded similarity in B:C ratio of hybrids Rampur hybrid 2 (1.29) and RML 32/RML 17 (1.25) in spring season of 2014 in Rampur, Chitwan.

Further, the B:C ratio (2.60) in zero tillage recorded was non significantly higher than conventional tillage (2.22) in this experiment. This result is also in line with Karki *et al*. [4] and Sharma (2015) in the same location. The B:C ratio obtained with 85 thousand plants ha^{-1} was similar to 69 and 101 thousand plants ha^{-1} but significantly higher than that of 55 thousand plants ha^{-1} owing to significantly higher gross returns obtained as a result of significantly higher grain yield (Table 2).

On the other hand, Karki *et al*. [4] reported significantly higher B:C ratio in the treatment with higher population of 66 thousand plants ha^{-1} (1.46) than 57 (1.16) and 53 (1.19) thousand plants ha^{-1} in spring season of 2014 in Chitwan. So, it depends on season and type of hybrid. Thus, both the hybrid maize varieties (Rampur hybrid 4, and Rampur hybrid 6) can be successfully grown under zero tillage system with optimum plant population of 85,000 plants ha^{-1} to achieve higher grain yield and net returns in winter season of western Chitwan, Rampur, Nepal.

5. CONCLUSION

Net returns and B:C ratio obtained from zero tillage (NRs. 1,03,473 and 2.6) were higher than conventional tillage (NRs. 83,924 and 2.22). Thus, both hybrid maize varieties (Rampur hybrid 4, and Rampur hybrid 6) can be successfully grown under zero tillage system with optimum plant population of 85 thousand plants ha^{-1} to achieve a higher grain yield and net returns in winter season of western Chitwan, Rampur, Nepal.

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