EUROPEAN ACADEMIC RESEARCH
Vol. XI, Issue 12/ March 2024

Impact Factor: 3.4546 (UIF)
DRJI Value: 5.9 (B+)

ISSN 2286-4822
www.euacademic.org

Effect of fertilizer placement in different depth for different tillage options on wheat yield

MD. ZAKIR HOSSAIN[1]
MOHAMMAD NUR ALAM
MD. SARIFUL BIN EKRAM
Bangladesh Wheat and Maize Research Institute, Nashipur, Dinajpur-5200, Bangladesh
MD. AKTARUL ISLAM
Bangladesh Institute of Nuclear Agriculture, Mymensingh, Bangladesh
MD. A. WADUD MOLLAH
SQ Agriculture Ltd., Bangladesh
MUSTAFA KAMRUL HASAN
CIMMYT- Bangladesh
MOSHARAF HOSSAIN
Bangladesh Agricultural Research Institute, Gazipur, Bangladesh

Abstract

An experiment was conducted at the farm of Bangladesh Wheat and Maize Research Institute, Nashipur, Dinajpur to develop a fertilizer application related device for existing seeder available in Bangladesh, to find out the effect of depth of fertilizer placement and the best fertilizer management in Resource conserving technologies (RCT) under different tillage options for wheat production. The experiment was laid out in a split-split plot design with three replications. The treatments were: in main plots - four tillage methods i). Power Tiller Operated Seeder (PTOS), (ii) Bed planting, (iii) Strip tillage, (iv) Conventional; in sub-plot - two depths of fertilizer placement (4±1 and 6±1cm) and in sub-sub plots - two fertilizers doses (100% and 75% recommended fertilizer) (RF). Results of the study indicated that grain yield of wheat was not influenced significantly by the interaction effect of fertilizer doses applied in different depth under different tillage options. Numerically higher grain was recorded in the plots where 4±l cm depth under PTOS tillage system the lower yield was found in bed planting system in 6±1 cm depths. Interaction effect showed plant population after 45 days, spike/m² and grain/spike were significant while remaining parameters were not significant.

Keywords: Resource Conserving Technologies, Fertilizer Placement, Tillage Options, Wheat Yield.

INTRODUCTION

In modern agriculture, optimizing fertilization methods is crucial for achieving both high nutrient use efficiency and crop productivity. This is essential to meet the rising global food demand while minimizing depletion of natural resources and environmental deterioration (Cassman, 1999; Cassman et al., 2003; Tilman et al., 2002).

Farmers increasingly adopt Resource Conserving Technologies (RCT) for their cost-saving benefits, soil conservation, and water efficiency, without compromising yields. RCT, including zero-till, bed planting strip tillage, and PTOS tillage, facilitates

[1] Corresponding author: zakzuberi@gmail.com

timely wheat planting, crucial in areas facing labor scarcity and rising cultivation costs. To ensure optimal crop yields with RCT, a comprehensive package of production technologies, notably efficient fertilizer management, is imperative.

Wheat (Triticum aestivum), a staple food globally, belongs to the Gramineae family and has its origins in southwestern Asia, spreading across Asia, Europe, Africa, and America (Yongqing, 2005; Bertholdsson, 2005). Suited for temperate regions with an annual rainfall of 10 to 70 inches, wheat faces challenges in high rainfall and temperature conditions conducive to diseases. Water conservation research emphasizes tillage systems, row spacing, seeding rate, rotation, and variety effects on wheat yields. Tillage impacts, influenced by soil type, moisture, and climate, can be optimized for higher yields through direct seeding into crop residue. Evidence suggests that residue from reduced tillage fosters changes in soil temperatures, benefiting soil health, plant growth, and the environment (Busari et al., 2015). Conservation tillage has demonstrated effects on soil water content (Wilhelm et al., 1986), soil microbial populations (Doran, 1980), and soil chemical properties (Schomberg et al., 1994).

Nash et al. (2013) discovered that strip-till and deep banding nitrogen (N) fertilizer significantly increased corn yield compared to no-till with broadcast N in poorly drained claypan soils. Borges and Mallarino (2001) studied improved potassium (K) application for corn in 15 sites, finding that deep-band K increased K uptake over broadcast K in 14 sites. Ma et al. (2013) reported that side-banded ammonium and phosphorus (P) enhanced maize growth, nutrient uptake, and grain yield on calcareous soil, linked to localized nutrient-induced root proliferation. In a three-year field experiment, Trapeznikov et al. (2003) observed higher wheat yield with banded NPK fertilizer at 8–10 cm depth compared to homogeneous application in the 0–18 cm soil layer.

Banding fertilizer saturates the soil solution, especially with slowly-mobile nutrients like P and K, in a confined root zone area. This reduces fixation and adsorption by soil particles, enhancing nutrient availability (Farmaha et al., 2013; Fernandez and White, 2012; McLaughlin et al., 2011). Deep-banded fertilizer in soil increases water availability in the subsurface, favoring nutrient-solution and nutrient-transport for higher nutrient availability (Li, 2008; McLaughlin et al., 2011). Localized N and P concentrations from banding stimulate ideal root architecture, increasing crops' nutrient uptake and yield (Shen et al., 2013). Beyond improving nutrient use efficiency and crop yield, banding fertilizer reduces nutrient loss. Rochette et al. (2009) reported a 52% decrease in ammonia volatilization by banding urea compared to broadcast in no-till soil. Cheng et al. (2002) found lower N2O + NO emissions from band than broadcast application on Chinese cabbage. Kimmell et al. (2001) observed significant P placement effects, reporting lower P runoff losses with knife placement compared to broadcast P. The interaction between P placement and tillage system in wheat production is an essential approach for cultivation and development (Nazim et al., 2008).

Achieving optimal crop yields with Resource Conserving Technologies (RCT) requires a comprehensive production technology package, with a particular emphasis on effective fertilizer management. In RCT practices, such as zero-till and bed planting, broadcasting fertilizer can lead to significant nutrient losses. This is a critical concern as it not only results in inefficient use of fertilizers but also poses environmental risks.
Contrastingly, there is a growing body of evidence suggesting that targeted fertilizer placement enhances fertilizer use efficiency compared to broadcast methods. Placing

fertilizers directly at the root zone of crops facilitates better nutrient uptake and utilization, contributing to improved overall plant health and productivity. This is especially crucial in conservation tillage systems where the preservation of soil structure and health is a primary objective.

However, despite the potential benefits of precise fertilizer placement in RCT, there is a notable gap in research and implementation in this regard, particularly in the context of different depths for wheat cultivation in this country. The scarcity of studies addressing the specific nuances of fertilizer management in RCT, such as the depth of placement, calls for dedicated research efforts.

Hence, the upcoming experiment aims to fill this research gap by systematically investigating the optimal rate of fertilizer placement and varying depths suitable for wheat cultivation. This study intends to provide valuable insights into how precise fertilizer management, aligned with RCT principles, can contribute to enhanced crop yields, reduced environmental impact, and sustainable agricultural practices in the specific agro-climatic conditions of the country.

In summary, the emphasis on the intricate relationship between fertilizer management and RCT practices, along with the scarcity of research on fertilizer placement depth, underscores the importance of the proposed experiment. It aspires to contribute valuable knowledge that can guide farmers, policymakers, and researchers toward more efficient and sustainable wheat cultivation practices tailored to the unique challenges and opportunities of the local agricultural landscape.

MATERIALS AND METHODS

An experiment was conducted at the farm of Bangladesh Wheat and Maize Research Institute, Nashipur, Dinajpur, Bangladesh (Lat 25.742913^0, Long 88.672948^0) to develop a fertilizer application related device for existing seeder available in Bangladesh, to find out the effect of depth of fertilizer placement and the best fertilizer management in RCT under different tillage options for wheat production. The experiment was laid out in a split plot design with three replications. The treatments were: 1). Four tillage methods (i). Power Tiller Operated Seeder (PTOS), (ii) Zero Tillage, (iii) Strip tillage, (iv) Conventional, 2). Two depths of placement (i). 4±1cm, (ii) 6±1cm and 3). Two fertilizer dozes (i) 100% RF, (ii) 75% RF. For maintain of proper depth placement of seed and fertilizer, after one pass tillage of PTOS, Bed planter and Strip tiller, manually earthed up and filled up soil then applied fertilizer and sown seed and used steel scale. The wheat variety BARI Gom-29 was used. The sowing date of wheat was 1st December/2015 and harvested date in the last week of 1st March/2016.One pre irrigation was applied to bring optimum moisture for planting and germination.

After well preparation of land, seeds were sown 120kg/ha continuously in 20 cm apart rows in 4 cm depth. For convention practice, tillage was three passes by power tiller and seeds and fertilizers applied by broadcasting method. All of TSP, MoP, Gypsum, Boric acid, zinc sulphate and 2/3 of urea was applied as during sowing time. The rest amount of urea was applied as top dress at crown root initiation (CRI) stage followed by first irrigation (at 20 DAS). The second irrigation applied at late booting stage (55 DAS) and third irrigation at early grain filling stage (75 DAS).

After full maturity, Number of tillers (Spikes) was counted and expressed into spikesm^{-2}. Grains were also measured from 10 spikes and expressed into grain spike^{-1}.

The crop was harvested plot wise according to treatments. The harvested crop of each sup plot was bundled separately, tagged and taken to threshing floor. The bundles were thoroughly dried in bright sunshine until fully dried, then weighed and threshed. Threshed grains of each subplot were again dried with sunshine and weighed; lastly grain yield was converted into kg/ha. To obtain the actual yield, grain yield weight was adjusted at 12% moisture. Data were analyzed using STAR.

RESULTS AND DISCUSSION

From the analysis of variance in the table 1.1 it was found that tillage option was significantly varied for plant population after 10 days, plant population after 45 days, spike/m^2; Fertilizer doses were significantly varied for plant population after 45 days and depth for TGW and grain yield were significantly varied. It was reviled that tillage and fertilizer interaction had significantly variation plant population after 45 days. And spike/m^2; tillage and depth interaction was significant plant population after 45 days; fertilizer and depth interaction for spike/m^2. Tillage, fertilizer, depth combined interaction had significant effect on plant population after 45 days, spike/m^2; Grain/spike

Table 1.1. ANOVA of combined analysis of yield and yield contributing characters

Sources of Variation	DF	Mean Square						
		Plant Population (10 Days)	Plant Population 10 Days	Spike/m^2	Spikelet	Grain/ spike	TGY (G)	Yield (Kg/ha)
Replication	2	400ns	5770ns	2998ns	2998ns	10ns	18ns	445608ns
Tillage	3	9734**	57417**	15116**	15116ns	10ns	8ns	573611**
Error(a)	6	177ns	1732ns	640ns	640ns	9ns	5ns	111086ns
Fertilizer	1	56ns	12192**	50ns	50ns	0.21ns	0.16ns	2700ns
Tillage x Fertilizer	3	505ns	7352%*	6196**	6196ns	4ns	Sons	116233ns
Error(b)	8	239s	1446ns	313ns	313ns	11ns	2ns	64750ns
Depth	1	8ns	2394ns	13ns	13ns	1ns	28**	410700**
Tillage x Depth	3	1262ns	9592%*	1452ns	1452ns	2ins	3ns	347655ns
Fertilizer x Depth	1	208ns	1575ns	3152**	3152ns	2.43ns	2ns	32033ns
Tillage x Fertilizer x Depth	3	745ns	5177**	2686**	2686ns	54**	2ns	117122ns
Error(c)	16	490ns	1148ns	692ns	692ns	12ns	7ns	54433ns
Total	47							
CV(a)%		7.64	10.53	8.84	3.03	6.09	5.31	8.21
CV(b)%		8.88	9.63	6.18	3.6	6.76	3.34	6.27
CV(c)%		12.7	8.57	9.19	3.53	7.03	5.94	5.75

* 1% significant, ** 5% significant, ns- Non-significant

Here, plant population after 10 days, plant population after 45 days, spike/m^2 and yield were significant, while remaining parameters were not significant. The highest plant population after 10 days was 208 in PTOS followed by 179,174 whereas the lowest value was 138 in BED planting. The highest plant population after 45 days was 454 in PTOS followed by 445 whereas the lowest value was 305 in BED planting. The highest spike/m^2 was 321 in CONV. followed by 307 whereas the lowest value was 240 in BED planting. The highest yield was found 4335 Kg h^{-1} PTOS and the lowest yield was 3800 Kg h^{-1} in BED.

Table 1.2. Grain yield as influenced by different tillage options

Tillage	Plant Population 10 Days	Plant Population 45 Days	Spike/m^2	Spikelet	Grain/spike	TGY(G)	Yield(Kg/ha)
PTOS	208	454	307	19	52	45	4335
BED	138	305	240	19	50	44	3800
STRIP	173	377	278	19	50	45	4048
Conventional	179	445	321	19	51	44	4053
Mean	174	395	286	18	50	44	4059
5%LSD	15	30	20	0.5	3	2	218
F-test	**	**	**	ns	ns	ns	**

Table 1.3. Grain yield as influenced by different fertilizer dose

Fertilizer dose	Plant Population 10 Days	Plant Population 45 Days	Spike/m^2	Spikelet	Grain/spike	TGY(G)	Yield(Kg/ha)
100%RF	175	379	287	18	50	44	4051
75%RF	173	411	285	18	50	44	4066
Mean	174	395	286	18	50	44	4059
5%LSD	11	21	14	0.38	2	1	154
F-test	ns	**	**	ns	ns	ns	ns

Here, only plant population after 45 days and spike m^2 yield were significant as influenced by different fertilizer dose in that table and other parameters were not significant. The highest plant population after 45 days was 411 in 75% recommended fertilizer dose whereas the lowest value was 379 in 100% recommended fertilizer. The highest Spike/m^2 was 287 in 100% recommended fertilizer dose whereas the lowest value was in 285 in 75% recommended fertilizer dose.

Table 1.4. Grain yield as influenced by different depths

Depth	Plant Population 10 Days	Plant Population 45 Days	Spike/m^2	Spikelet	Grain/ spike	TGY (G)	Yield (Kg/ha)
6±1cm	174	402	286	18	50	43	3966
4±1cm	173	388	285	18	50	45	4151
Mean	174	395	286	18	50	44	4059
5%LSD	11	21	14	0.38	2	1	154
F-test	ns	ns	ns	ns	ns	*	**

Here, yield was showed statistically significant as influenced by different depth of fertilizer- placement. The highest yield was 4151 (Kg h^{-1}) found 4±1 cm depth placement of fertilizer and lowest yield was 3966 (Kg h^{-1}) found 6±1 cm depth placement of fertilizer. Thousand grain weights was 10% level of significant for the variation of depths.

Here, plant population after 45 days, spike/m* and grain /spike were significant, while remaining parameters were not significant. The highest plant population after 45 days was 514 in conventional tillage, 75% recommended fertilizer dose and 4±1 cm depth placement of fertilizer whereas the lowest value was 270 in bed planting, 100% recommended fertilizer, 4±1 cm depth placement of fertilizer. The highest Spike/m^2 was 376 in conventional tillage, 75% recommended fertilizer dose, 6±1 cm depth placement of fertilizer whereas the lowest value was 218 in bed planting, 75% recommended fertilizer dose, 4±1 cm depth placement of fertilizer. The highest Grain /spike was 56 in PTOS tillage, 75% recommended fertilizer dose and 4±1 cm depth placement of fertilizer whereas the lowest value was 48 in various treatment.

Table 1.5. Interaction effect of yield and yield parameters imposed by tillage, fertilizer and depth

Tillage	Fertilizer dose	Depth placement fertilizer	Plant Population 10 Days	Plant Population 45 Days	Spike/m^2	Spikelet	Grain/ spike	TGY (G)	Yield (Kg/ha)
PTOS	100%RF	6±1cm	200	486	328	18	53	45	4133
PTOS	100%RF	4±1cm	200	392	307	18	50	44	4433
PTOS	75%RF	6±1cm	237	459	315	18	48	44	4060
PTOS	75%RF	4±1cm	192	476	276	18	56	47	4713
BED	100%RF	6±1cm	143	314	260	18	48	42	3973
BED	100%RF	4±1cm	149	270	256	19	53	44	3546
BED	75%RF	6±1cm	141	302	225	18	50	43	3806
BED	75%RF	4±1cm	127	334	218	18	48	44	3873
STRIP	100%RF	6±1cm	170	410	279	18	50	44	4186
STRIP	100%RF	4±1cm	175	366	291	18	49	44	4186
STRIP	75%RF	6±1cm	174	414	258	19	52	45	3940
STRIP	75%RF	4±1cm	170	314	282	18	48	46	3880
Conventional	100%RF	6±1cm	181	356	251	18	49	43	3646
Conventional	100%RF	4±1cm	192	437	325	18	50	47	4300
Conventional	75%RF	6±1cm	150	473	376	18	53	42	3986
Conventional	75%RF	4±1cm	192	514	330	18	48	44	4273
Mean			174	395	286	18	50	44	4059
5%LSD			31	61	40	1	5	4	436
F-test			ns	**	**	ns	**	ns	ns

CONCLUSION

While numerous strategies for wheat cultivation have been explored globally to enhance wheat production, this study uniquely focuses on the specific context of Bangladesh, delving into the impact of fertilizer placement under different tillage options. The methodologies applied in wheat cultivation, as investigated in various countries, may serve as regulatory and efficacious measures to attain elevated wheat yields. The experimental results indicate that Plant population is higher in conventional method where fertilizer dose was 75% RF with depth of fertilizer placement was 4 cm and lower was BED planting 100% RF with 4 cm depth of fertilizer placement but yield was higher in PTOS in 75% RF with 4 cm depth and lower was BED planting 100% RF with 4 cm depth placement of fertilizer. This is one year experimental results.

Acknowledgements

The authors would like to thank Bangladesh Wheat and Maize Research Institute (BWMRI), Nashipur, Dinajpur for providing all facilities and sharing their expertise for resource conserving technologies.

REFERENCES

1. Cassman, K.G., 1999. Ecological intensification of cereal production systems: yield potential, soil quality, and precision agriculture. Proc. Natl. Acad. Sci. USA 96, 5952–5959.
2. Cassman, K.G., Dobermann, A., Walters, D.T., Yang, H., 2003. Meeting cereal demand while protecting natural resources and improving environmental quality. Annu. Rev. Environ. Resour. 28, 315–358
3. Tilman, D., Cassman, K.G., Matson, P.A., Naylor, R., Polasky, S., 2002. Agricultural sustainability and intensive production practices. Nature 418, 671–677.
4. Yongqing MA. 2005. Allelopathic studies of common wheat (Triticum aestivumL.). Weed Biology and Management 5(3), 93-104. https://doi.org/10.1111/j.1445-6664.2005.00164.x
5. Bertholdsson NO. 2005. Early vigor and Allelopathy-Two useful traits for enhancing barley and wheat competitiveness against weeds. Weed Research 45(20), 94. https://doi.org/10.1111/j.1365-3180.2004.00442.x
6. Busari MA, Kukal SS, Kaur A, Bhatt R, Dulazi AA. 2015. Conservation tillage impacts on soil, crop and the environment. International Soil and Water Conservation Research 3(2), 119-129. https://doi.org/10.1016/j.iswcr.2015.05.002

7. Nash, P.R., Nelson, K.A., Motavalli, P.P., 2013. Corn yield response to timing of striptillage and nitrogen source applications. Agron. J. 105, 623–630.
8. Borges, R., Mallarino, A.P., 2001. Deep banding phosphorus and potassium fertilizers for corn managed with ridge tillage. Soil Sci. Soc. Am. J. 65, 376–384.
9. Trapeznikov, V.K., Ivanov, I.I., Kudoyarova, G.R., 2003. Effect of heterogeneous distribution of nutrients on root growth, ABA content and drought resistance of wheat plants. Plant Soil 252, 207–214.
10. Farmaha, B.S., Fernández, F.G., Nafziger, E.D., 2013. Distribution of soybean roots, soil water, phosphorus and potassium concentrations with broadcast and subsurface-band fertilization. Soil Sci. Soc. Am. J. 76, 1079–1089.
11. Fernández, F.G., White, C., 2012. No-till and strip-till corn production with broadcast and subsurface-band phosphorus and potassium. Agron. J. 104, 996–1005.
12. McLaughlin, M.J., McBeath, T.M., Smernik, R., Stacey, S.P., Ajiboye, B., Guppy, C., 2011. The chemical nature of P accumulation in agricultural soils—implications for fertilizer management and design: an Australian perspective. Plant Soil 349, 69–87.
13. Shen, J.B., Li, C.J., Mi, G.H., Li, L., Yuan, L.X., Jiang, R.F., Zhang, F.S., 2013. Maximizing root/rhizosphere efficiency to improve crop productivity and nutrient use efficiency in intensive agriculture of China. J. Exp. Bot. 64, 1181–1192.
14. Rochette, P., Angers, D.A., Chantigny, M.H., MacDonald, J.D., Gasser, M., Bertrand, N., 2009. Reducing ammonia volatilization in a no-till soil by incorporating urea and pig slurry in shallow bands. Nutr. Cycl. Agroecosyst. 84, 71–80.
15. Cheng, W., Nakajima, Y., Sudo, S., Akiyama, H., Tsuruta, H., 2002. N2O and NO emissions from a field of Chinese cabbage as influenced by band application of urea or controlled-release urea fertilizers. Nutr. Cycl. Agroecosyst. 63, 231–238.
16. Kimmell, R.J., Pierzynski, G.M., Janssen, K.A., Barnes, P.L., 2001. Effects of tillage and phosphorus placement on phosphorus runofflosses in a grain sorghum–soybean rotation. J. Environ. Qual. 30, 1324–1330.
17. Nazim H, Khan MB, Ahmad R. 2008. Influence of phosphorous application and sowing time on performance of wheat in calcareous soils. International Journal of Agriculture and Biology 10(4), 399-404.