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Engineering management of rice-residue in rice-wheat cropping system of Indo-Gangetic plain, A Review

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Abstract

In Pakistan and India wheat is cultivated after the rice harvesting. Some varieties of rice take extra time to harvesting which leads in the delayed wheat sowing. Normally combine harvester is used for harvesting of rice which collects mature crop plants from field and put residue in the field. Residue management is a big headache for farmers, traditionally it is burn in the field before tillage operation for land preparation. Researches were conducted on zero seed drill, zero till ferti drill, cultivator cum seed drill for wheat sowing in residue field. After that Happy Seeder was manufactured which works on zero tillage principle, mulch the rice residue and sow seed in the field. It was tested in different location of India and Pakistan. Its operational cost is very less than other methods used of sowing of wheat. Therefore it is recommended for wheat sowing in rice residue. For timely sowing of wheat in rice stubble field there is a need of advance technology on this issue, objective oriented polices and changes in the institutional planning and development. In the resent work, we highlighted the potential impact of happy seeder in rice wheat cropping system. Additionally, the review also highlights the impacts of rice residue burning on soil fertility, beneficial insects, air and environment.

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Introduction

Purpose of this review paper is to study different engineering prospects and their scope used to manage combine harvester rice stubbles fields before wheat sowing in the rice-wheat cropping system of Indo-Gangetic plain. Generally farmer prefer to burnt residue as an easy and cost effective method, which result in potential loss of organic matter, microbes, insects beneficial for crop growth and causing environmental pollution.

Study covers the challenges due to burning of rice stubbles on the environment, climate and advancement in the sowing method from broadcasting to advance conservation method, happy seeder for wheat sowing in wheat-rice cropping system of this plain. Another importance of this plain is that it covers the two important caloric foods of the world.

Internationally, rice covers 11 percent of world agricultural land. Asia dominates the world in rice production as it accounts for about 90 percent of world's rice area and 92 percent of production (Kavya Doshora; Ravi Khetarpal; 2013).

Agriculture is ranked top among Pakistan's financial industries susceptible to climate change's potential effects. Agricultural manufacturing system is directly influenced by climate inputs (temperature, solar radiation, and precipitation) that are expected to alter in the future (after carbon dioxide and other greenhouse gasses increase). While climate extremes such as drought, floods and heat waves are expected to rise with detrimental effects on farming and livestock production, changes in mean climate also pose challenges to sustainable development. This study presents the results of climate change for five districts within the province of Pakistan's major rice-wheat productivity zone. (Rasul, Ruane, Hoogenboom, & Ahmad, 2017).

Rice- Wheat Cropping System and Issues

While rice and wheat are the main sources of calories for over one billion in South Asia, each crop is particularly vulnerable to its growing climate and agronomic circumstances. Seasonal heat stress can decrease photosynthesis and accelerate senescence; if there is severe thermal stress while flowering, the pollen viability and stigma deposition of both rice and wheat can decrease and increase grain sterility.

If farmers cannot adapt to the season, significant variations from anticipated climatic circumstances would have an effect on crops development, yield and consequently a major impact on food security. In the growing chambers, greenhouses and research station studies, we have extensively researched the impact of climate circumstances on plant development, although empirical data show that climate variability and yield risk are relatively scarce in farmers areas. This article reacts to this gap and isolated the impacts of agronomic management on rice and wheat yield hazards from climate variability in eight of Pakistan's twelve agro-ecological regions by information obtained from 240 agricultural homes. We examined the impacts of crop management and climatic circumstances on yield and yield variability of individual crops using the just and pope production functions. Our findings show significant hazards to the capacity of farmers to achieve reliable rates for both crops. Although the input and crop management variability was variable, there has been proof of the adverse impact of both seasonal and terminal heat stress, as we were aware of the cumulative amount of days of growing crops above critical limits, although the sensibilities of wheat were significantly higher than rice. The comparison with medium-term trends, rice and wheat rates in the research years were both negatively impacted, indicating the danger for manufacturing and the restricted ability of farmers for adaptation during the season. We find it important to review current policies on adaptation to climate change aimed at boosting the resilience of cereal farmers in Pakistan and South Asia more widely. The further inquiry proposes potential agronomic and expansion approaches (Arshad & Krupnik, 2016).

The simplest and cheapest choice to manage plant / biomass residues is burning. It is commonly practiced everywhere because of the absence of consciousness or the absence of adequate technology.

The combustion of cultivated residues not only degrades the atmosphere but also damages the environment and ultimately human health.

The aerosols affect regional and possibly global, radiation budgets by their light-scattering effects and influence on cloud microphysical processes. Various studies have been published dealing with the amount of biomass burned from various sources such as deforestation, shifting cultivation, savanna fires, fuel wood and the burning of agricultural residues mainly in tropical regions (Wang *et al.*, 2007, Cao *et al.*, 2008, Zhang *et al.*, 2011).

Rice–wheat cropping sequence (RWCS) is the world's largest agricultural production system covering round 12.3 Mha in India, 0.5 Mha in Nepal, 2.2 Mha in Pakistan and 0.8 Mha in Bangladesh and around 85 percent of this area falls in Indo- Gangetic plains (IGP) (Ladha *et al.*, 2003; Timsina & Connor 2001).

The strength and temperature resistance of concrete effects of rice husk ash (RHA) have been explored. Various quantities of cement in concrete have been substituted, under steady condition of a binder content, by RHA and Fly Ash (FA), used as mineral admixtures. Different temperatures were evaluated for compressive strength and temperature resistance. The findings indicate that blending concrete with RHA can enhance its strength by blending the suitable quantities. At 800 oC, the resistance of normal concrete (NC) is 50 per cent higher. RHA is thus able to enhance the resistance to concrete strength and temperature (Wang, Meng & Wang, 2017).

The continuous sequential cropping has observed problem of stagnation of the rice-wheat productivity in many countries. Evidence from some long-term experiments shows that problems of stagnating yields and even yield declines are occurring in the rice-wheat system of South Asia (Regmi *et al.*, 2002).

Soil organic matter is also declining; new weeds, pests, and diseases are creating more problems, whereas irrigation water is scarce. Farmers complain that their products have elevated expenses of input and low prices. Excess manufacturing marketing is a burden on farmers and storage is a government issue. Consequently, there is a enormous challenge in the region to satisfy future food demand without damaging the foundation of natural resources, to produce food at a price that to encourage farmers to enhance their livelihoods and eventually reduce poverty (Sheikh & Abbas, 2007).

Conservation Agriculture (CA)

The disposal of paddy residues in Northwest Indian States has turned out to be a big issue, which means that farmers prefer to burn the residues in situ. The management of paddy residue is of great importance because it includes plant nutrients and increases the air continuum of the soil-plant. The combustion of biomass is not only environmentally polluting and leads to significant loss of essential nutrients from plants. The aims of the review document are to access residue generation quantity, their use on site and ex-situ, and to highlight the damaging impacts of waste combustion in north-west India especially in Punjab and Haryana on human health, soil and the environment. This article also explores the possible strategies, economic and socio-economic assessment of paddy residue management techniques and stresses the assessment of the spectrum of feasible policy tools that provide sustainable agriculture and the environment. In order to handle the residue of paddy on-site, timely accessibility of conservation agricultural machines (CA) is extremely important. It is cumbersome to collect and transfer voluminous mass of paddy residues, so the management of ex-situ residues is still not economically feasible. Farm waste opens up vibrant possibilities for its multiple uses and can be obtained and managed correctly if the waste is collected. For CA, excess residues are a prerequisite. Farmers want to be made aware of the significance of crop residues within CA for the sustainability and resilience of indigenous farming (Lohan *et al.*, 2018).

The recycling of these residues increases the physical, chemical and biological characteristics of soil. Rice residues are significant natural sources. Rice stroke management is a significant challenge because of its elevated silica content it is seen as a bad animal feed.

In order to evaluate the potential of rice residues and their management, residue impacts and crop productivity, a field experiment was performed over a period of 03 years. A 7 t ha−1 sequence of rice and 4 t ha−1 sequence of wheat removes over 300 kilograms of N, 30 kilograms of P, and 300 kyotograms of K ha-1 from the soil. Farmers need to manage 7 t ha-1 of rice residues and overcome the problems for planting wheat. The result of burning showed enormous loss of N (up to 75%), P (25%) or K (21%) before weed plantation and reduced the accessible N, P and K contents of soil to removal and combustion of residues of both rices–wheat rotation crops. The total system productivity improved by 10.0 to 15.8% when the residue is retained with continuous broad planting beds and the zero tillage scheme is planted compared to standard ones. Surface retention of soil N, P, and K decreases by 14.6, 28.5 and 17.7%. The physical properties of land, soil humidity, composite forming and bulk density are influenced by soil management practices. Extensive tillage with related heavy expenses can be decreased. There are thus improvements in soil properties and support the sustainability of crop productivity when residues are managed correctly. (Naresh, 2013).

The seeding machine should be appropriate for all farms, all kinds of crops, solid design and reliable as well, this is a fundamental accommodation machine requirement. We therefore manufactured the manually operated seeding machine that decreases farmers ' work, thereby improving planting effectiveness, which also decreases the manual seeding issue. We can also plant various kinds and distinct sizes of plants for this machine, but we may also change the room between seeds. The planting effectiveness and precision also improved. So it was so inexpensive and useful to small farmers from raw materials. For effective handling of the machine by any farmer or by any untrained worker we simplified its design. Also its adjusting and maintenance method also simplified (V, Kasturi, V, & N, 2017).

In India, rice-wheat cultivation is very frequent. The crop structure contributes to more than 70 percent of the total manufacturing of food grains in the nation with 12 M ha. The region is, however, estimated at between 42.31 and 22.98 M ha for rice and wheat crops respectively. In order to analyze the efficiency of zero-till seed cum ferti-drill along with another scheme of wheat seeding, a research was carried out in the farmer sector of Ambedkar Nagar District. The zero tilling method for planting wheat after rice can be implemented effectively using a zero till ferti seed drill (ZTFDS) for seeding which has been established at GBPUA&T, Pantnagar and is now commercially produced. Although it is becoming extremely common in Haryana and Punjab states, this technique of seeding wheat with zero-till seed cum ferti drill is not common in central Uttar Pradesh in particular. In comparison to standard sowing methods, the zero-tillage seeding saves time (88 percent) and is energy-efficient (79 percent). Whereas the traditional sowing technique may be used for seeding 10-15 days in advance. This results the wheat crop to be sown quickly and production increases. The average irrigation cost of zero till ferti seed drill (T4) is 2592.0 Rs/ha , 667.5 Rs/ha less than standard irrigation, and saves 21%. The zero-till ferti-seed drill is successful and does not cause problems in the field during operation.

The farmers from District Ambedkar Nagar (U.P.) discovered that zero till ferti seed drill scheme provides a high advantage (1.76) compared to standard systems as a result of the appropriate device of the district farmers Ambedkar Nagar (U.P.) (Papu Singh, Singh, Singh, & Mishra, 2014).

Direct drilling helps in timely sowing of wheat after paddy in paddy-wheat rotation. It decreases manufacturing costs, regulates soil erosion weeds, preserves soil humidity and also improves soil organic matter quantities. Due to the loose straw and chaff spread over the field after mixing, it is not however feasible to directly drill in the combined harvested paddy field (Shukla L.N., *et al.*, 2002).

The rota drill was been designed to promote line sowing, ensure timely planting of wheat and to save fuel cost and energy because it takes only one pass of a tractor to complete the operation in the field (Muhammad Yasin ; Ali, 2009).

Zero Tillage Technology

Rautaray (2005) reported on the results of zero tillage equipment-that management of crop residues in the rice-wheat cropping system and describes the need for continued attempts. The findings showed that over standard practice, no-tillage drilling was time, energy and cost-effective at 70.15, 67.16 and 66.39 percent respectively. Direct drilled wheat performance showed that, although the grain yields were equal in direct drilling schemes, the benefit-cost ratio was 15.2-23.4 percent greater with operating energy savings of 8.4-14.7 percent compared to standard practice.

Dixit *et al.* (2003) conducted the studies on no-tillage and conventional tillage system during rabi 1998 in Kaithal district of Haryana. The results represent that the wheat sown by no-till seed fertilizer drill gave 17.09 per cent higher yield as compare to conventional sowing. No-tillage system required least energy, while these requirements were about 5.5 times more in the conventional system. A net saving of `2140 ha-1 was observed with the adoption of no-till sowing of wheat crop over conventional method.

Grover and Tarun (2011) examined the impact of zero tillage technology in rice- wheat system in Punjab. Two districts viz. Patiala and Sangrur were selected for the study. The results showed that total cost of cultivation was `14881 and `17500 on the zero till farms and conventional farms respectively. The yield recorded was larger on zero tilled farms (52.18q ha-1 valued at `32876 than conventional method (50.55 q ha-1, valued at 31826). Study asserted that the adoption of zero tillage technology improved farmer‟s profit, livelihood and eventually reduce poverty.

Implementation of resource conservation technologies (direct seed aerobic rice and no-tillage wheat) in rice-wheat crop systems under different soil textures did not adversely affect grain yield and improved farm profitability by improving soil properties and reducing production costs. In no-tillage wheat, Total N and SOC were the highest in plow-tillage wheat. No- tillage or plow-tillage wheat performance was better compared to puddled flooded transplanted rice when grown after direct seeded aerobic rice. This study would suggest that farmers in the rice-wheat zone should grow direct seeded aerobic rice followed by no- tillage wheat to improve soil properties, profitability and sustainability of rice-wheat cropping system. The rice was much more responsive to conservation goals and that to improve wheat production may require more research. These findings may be applicable to other rice-wheat zones in South Asia on Haplic Yermosols under variable climatic conditions. However, the water input may vary depending upon the soil type and climate (Nawaz, Farooq, Lal & Rehman, 2017).

For field evaluation of strip till seed drill for wheat crop to study the effect of depths of sowing (cm) and speed of operations (km/hr) on various dependent parameters like field capacity(ha/hr), field efficiency (%), fuel consumption(l/ha) and wheel slippage (%). The study also revealed that depth of sowing and speed of operation significantly affected fuel consumption, wheel slippage, field capacity and field efficiency. The study was conducted at Research farm, SU Gangoh. Agronomic data recorded during the field evaluation showed that the fuel consumption and slip were 9.02 l/ha and 1.706% (minimum) at 2.5km/hr forward speed and 3.5cm depth whereas field efficiency was found to be 78.42 % (maximum) at corresponding speed and depth. The field capacity was found to be proper at 2.5km/hr forward speed and 4.5cm depth. The cost of seeding with strip till seed drill was calculated to be Rs.1258.97/ha and seeding with conventional method (tillage and broadcasting) costs Rs.1722.34/ha. The net saving by strip till seed drill was calculated to be Rs.463.36/ha in comparison to conventional method of sowing (Malik, Kumar, Sharma & Kumar, 2017).

The zero till fertilizer seed drill was found energy efficient and cost efficient compared to conventional sowing of wheat on the basis of energy ratio, specific energy and benefit cost ratio. As timely sowing of wheat is a major problem in Rice-Wheat cropping pattern. The use of zero tillage technology besides being economical, time saving, energy efficient, manages weeds, soil along with its moisture and advances sowing time.

Adoption of zero tillage technology enabled farmers to plant wheat about 10-15 days earlier conventional practice. Early planting resulted in 11% additional grain yield over conventional practice. The average yield in zero-tillage method was recorded 24.42q ha-1 over conventional sowing it is 22.08q ha-1 . The B:C ratio was observed higher side in zero-tillage method is 2.56 as compared to conventional method sowing of wheat is 2.03. The additional wheat production from Zero tillage technology gives about Rs. 6732/- per hectare additional income. Short duration varieties of paddy with line sowing and use of zero seed cum fertilizer seed drill in seeding of Rabi crops; increase the prospect of double cropping under rainfed condition. The farmers were convinced of the above interventions (P. D. Verma & Tamrakar, 2017).

Happy Seeder Technology

In Punjab, India, the combustion of rice stubble is common because there is no proper machinery that will direct drill wheat into combined residues of rice. Although burning is a fast and cost effective way, it is caused by air pollution, decreased fertility of soils owing to loss of nitrates and organic matter and greenhouse gas (GHG) emissions, which have a severe influence on human and animal health.

The recently developed Happy Seeder (HS) overcomes the technical problems associated with direct drilling into rice residues. The primary aim of the present study was to conduct a preliminary evaluation of the direct financial benefits and costs to farmers of use of the HS in comparison with the current practices of straw burning followed by direct drilling or conventional tillage prior to sowing. The results of the evaluation suggest that the HS technology is more profitable than conventional cultivation or direct drilling after burning, and that it is viable for farmers from a financial perspective. For widespread adoption of the technology, a range of potential mechanical, technical, social, institutional and policy constraints need to be considered and addressed in conjunction with a detailed economic assessment of the HS technology (R.P. Sihgh, H.S. Dhaliwal, Humphreys, Singh & Singh, Yadvinder-singh, 2008).

Dhaliwal *et al.* (2011) conducted a study in Punjab and Uttar Pradesh states. A sample of 39, 38 and 38 farmers who have sown their wheat with Happy Seeder was taken during the years 2007-08, 2008-09 and 2009-10 respectively for the purpose of the study. Study determined that there was a saving of `5,912 ha-1 from Happy Seeder Technology (HST) over conventional tillage. It was observed that net returns were quite high from Mungbean when sown with HST as compared to Conventional Tillage. Comparative economics were better when wheat was sown with Happy Seeder as HST brought about improvement in physical condition of soil and improvement. Use of HST also reduced the terminal heat stress and saved on pre-sowing irrigation leading to reduction in time taken for first and second irrigation.

Gupta (2012) selects the state of Punjab for research. Representative farmers specimens were chosen from Amritsar, Ludhiana and Sangrur counties to capture geographic variety across Punjab. The Happy Seeder Technology was, according to the research, a feasible solution to open-field rice residue burning in Punjab. The results revealed that this technology could save about `1000-1060 ha-1 (or USD 23) on average in field preparation costs compared to plots that were conventionally tilled. Study also pointed out that farmers enjoy substantial time savings because the Happy Seeder could be brought into the field immediately after the rice harvest. The findings indicated that this technology could save on average in the cost of field preparing around' 1000-1060 ha-1 (or USD 23) compared to conventionally tilled plots. Study also pointed out that farmers enjoy significant time savings because immediately after the rice harvest, the Happy Seeder could be carried into the field. Overall, the research suggested that policymakers and other stakeholders play a more proactive role in encouraging the use of the Happy Seeder machine to decrease burning of residues. The research therefore suggested that the government encourage the machine through grants.

Avtar *et al.* (2013) carried out research in district of Jalandhar, Kapurthala, Patiala and Fatehgarh Sahib to accelerate technology of Happy Seeder and rotavator for sowing of wheat in the combine harvested fields for *in-situ* management of paddy straw during 2009-10. The study concluded that Happy Seeder was best method to reduce the cost of production and manages the combine harvested paddy straw. Findings reveal that, sowing of wheat with Happy Seeder could save time 4.31 hrs and `2250 ha-1 over the rotavator and, fuel 16.03 liters diesel, time 5.38 hrs and `3250 ha-1 over the farmers‟ practice. The average grain yield of four districts of wheat sown with Happy Seeder was higher than wheat sown with rotavator (1.06 qha-1) and farmer‟s practice (1.03 qha-1). Therefore, the farmers are advised to adopt the Happy Seeder Technology for sowing wheat in the combine harvested fields.

The Happy Seeder is a tractor-mounted machine that cuts and lifts rice straw, sows wheat into the bare soil, and deposits the straw over the sown area as mulch. It therefore enables farmers to seed grain without the need to burn any residue of rice for preparing the soil just after their rice harvest. The first prototype of the Happy Seeder was created in July 2001 by the engineers of CSIRO Griffith at the University of Punjab in agriculture (Ridhima Gupta, Rufus Bellamy, 2012). The cost to use the Happy Seeder includes the cost to hire the machine, the cost of diesel, the amount spent on weedicide and the amount spent on the acquisition of fertilizers and weedicides. The Happy Seeder requires the uniform distribution of rice straw on the field–adding additional costs for the use of the machine. The full cost of wheat production with standard laying includes the cost of renting farm machinery, the expenses of operating it on diesel, the purchase and application of weedicide and fertilizers (Ridhima Gupta, Rufus Bellamy, 2012).

The rotation of the wheat crop in Punjab covers approximately 28.40 lakh of cultivable land is dominant in Punjab. This paddy–wheat rotation also evaluates fresh technology's ability to deal with the issue, i.e. happy seeder technology. For all combination harvesters the straw management system should be needed. The total 28 field demonstrations on happy seeder technology were conducted in village Killi Nihal Singh of district Bathinda of Punjab state during the years 2013-14 & 2014-15. The results of this technology have been shown that nutrients like urea, DAP and potash fertilizer, saved at rs. 424.15; rs. 366.25 and rs.1989, respectively, totals of Rs. 2779.40/hectare in addition to enhancing the value of enhancing. in the village Killi Nihal Singh, Bathinda District, state of Punjab, were revealed in the years 2013-14 and 2014-15. The largest increase of B: C in the 2013-2014 year of happy seeds was 4,36.

In addition to the saving in paddy burning, during the field preparation, sowing and management activities, a happy seed technology saved Rs 2311.25 per hectare on ordinary sown wheat. This Happy Seed Technology is a fresh initiative in the framework of paddy burning under Krishi Vigyan Kendra Batherinda, which will be useful for the dixitwhole of society because of environmental pollution control. The district of Bathinda lies in the south-west of Punjab, which is far less mechanised in agriculture than in other government constituencies (Dhillon, 2016).

The research has been carried out in the region of Allahabad on happy seeders for wheat sowing in rice-wheat cropping zone. In this research, the performance of the happy seeder is evaluated using the standard method and the efficiency of the seeding technology is shown. In order to demonstrate their effectiveness, the performance evaluation was performed on the grounds of field capacity, field efficiency, real field capacity, energy consumption and operating costs, compression of the operating economy of a happy seeder with a standard sowing technique for seeds of wheat from a mixed paddy field. To evaluate the variables, the operating speed varied between 2,5 to 3,5 kmph.

For seed drilling at operating speed of 3,5 kph, the field efficiency of the happy seeder was 43,4 percent and 65,04 percent. The plant residues are heavy and sampled. The operation costs for the happy seeder per hectare amounted to Rs. 2098.65 and the operation costs per hectare were Rs. 3106.38. Therefore, operating costs are reasonably economical compared to Rs. 1008.38 per hectare seed drilling. But happy seed is the only way to seed wheat in combination paddy field. The weeds are also controlled (Prashant Singh, Gautam & Yadav, 2017).

In India's comprehensive rice-wheat scheme, harvesting is largely combined and the residues of rice are usually burned after harvest, irrigation and intensive laying are performed before seeding wheat. The retention of crop residues on the ground can have a significant part in soil quality improvement and pollution reduction from stubble burning, but no appropriate technology has been developed to sow wheat in rice residues until very recently.

To address this need, a series of machines ('Happy Seeders') was developed over the past 10 years, culminating in the development of version 2 of the 9-row Turbo Happy Seeder (v.2). The 9-row Turbo Happy Seeder (v.2) has a weight of 506kg and can be operated by a33.6kW tractor at a work rate of 0.3 ha h−1. Many on-farm studies indicate that weed production in the 9-row Turbo Happy Seeder residues is greater than conventional tillage yields, while offering the farmer a great deal of advantage. These include a significant reduction in fuel utilization and farming costs and the capacity to sow as quickly as desired after harvest and decreasing irrigation needs (Sidhu *et al.*, 2017).

Conclusion

In rice residue field different sowing machinery is being used. However, after reviewing different researches it is suggests that Happy Seeder is best machine for sowing of wheat in rice stubble field.

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