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Influence of rice establishment method on NUE and WUE in chickpea under rice-pulse cropping system in a vertisols

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Abstract
The present investigation was carried out during 2017-18 and 2018-19 at Research farm, Indira Gandhi Krishi Viswavidyalaya, Raipur to evaluate the "Influence of rice establishment method on Nutrient use efficiency and Water use efficiency in chickpea under rice- pulse cropping system in a Vertisols. Influence of rice establishment method and water and nutrient management practices in chickpea under rice- chickpea cropping system on nutrient use efficiency and water use efficiency in post rice, chickpea crop were evaluate. Nutrient use efficiency, physiological efficiency, internal efficiency, recovery efficiency and partial factor productivity of nitrogen under chickpea was found significantly higher under direct seeded rice than puddled and unpuddled transplanted rice establishment method. Water use efficiency was found significantly higher in direct seeded rice establishment method. Under rice chickpea cropping system, on the basis of nutrient use efficiency, agronomic efficiency, physiological efficiency, internal efficiency, apparent recovery, partial factor productivity and water use efficiency, the performance of direct seeded rice establishment method was best during *rabi* followed by unpuddled transplanted rice. Direct seeded rice establishment method of rice followed by unpuddled transplanted rice for chickpea proved to be more remunerative as compared to the other treatments as above fact.

Keywords: Rice, chickpea, puddled, direct seeded, efficiency

Introduction
Chickpea is an important grain legume crop in the world approximately 73% of global chickpea growing area is in south and south-east Asia. India is the world's largest producer, importer and consumer of pulse. Over the year, while the country has accumulated huge surplus of wheat and rice, the pulse remain in short supply. Consequently, the per capita availability of pulses has progressively declined from 65 gm a day in 1961 to merely 39.4 g in 2011, whereas availability of cereals has gone up from 399.7 to 423.5 gm. For a country that faces persistent protein inflation and has preference for vegetarian diet, pulses are the most economical sources of vegetable protein. Higher consumption of pulses will help address the scourge of pervasive malnutrition caused by protein deficiency among large sections of Indian population. It is mainly grown as a rain fed crop during the *Rabi* season on conserved soil moisture from the preceding monsoon. However, with the expansion of irrigation facilities, the crop can be raised successfully under limited moisture condition. The water requirement of chickpea varies from place to place due to variation of agro-climatic and soil conditions (Ray *et al*., 2001) [10]. The consumptive use of water (evapo-transpiration) depends on the soil moisture supply and yield level. Evapo-transpiration should range from 110-240 mm to get a good yield of chickpea. Chickpea is a leguminous crop, fixes atmospheric nitrogen through symbiosis, therefore improving soil fertility and productivity of subsequent cereal crop. It is generally, believed that increasing crop residue levels leads to water conservation. However, crop residue that is removed from the field after harvest is gaining value for use in livestock rations and bedding, and as a source of cellulose for ethanol production. The water conservation value of crop residue needs to be quantified so crop producers can evaluate whether to sell the residue or keep it on their fields (Klocke *et al*., 2009) [5]. The effects of no-till and conventional tillage on soil and water dynamics are controversial by Strudley *et al*., (2008) [16], showed that except for an increased soil water retention time for no-till, all other effects due to no- till were inconclusive. Producers have expressed concerns about production practices where high levels of crop residue are present on the soil surface. These concerns include the increased use of chemicals, and wetted soil and lower soil temperatures delaying planting and retarding plant development during early vegetative growth, and less uniform germination and emergence using planting equipment that cannot operate adequately in the residue.

Standing residue helps to conserve water by causing snow to settle, rather than blow to field boundaries, by slowing the wind velocity just above the residue (Steiner, 1994) [15]. Subsequent melting snow is more likely to infiltrate into the soil because the stubble slows runoff, enhancing soil water storage. This water can then be used for crop production in the subsequent growing season. When the soil surface is wet from a recent irrigation or precipitation event, evaporation from bare soil will occur at a rate controlled by atmospheric demand. The evaporation rate decreases as the soil surface dries over time because water that is deeper in the soil is not transported to the surface quickly enough to maintain the rate of wet-soil evaporation; the drying surface soil starts to act as a barrier to water transport (Lascano and van Bavel, 1986) [7]. If the soil surface is covered with residue, it is shielded from solar radiation, and air movement just above the soil surface is reduced. This reduces the evaporation rate from a residue-covered surface as compared to bare soil (Aiken *et al*., 1997) [1]. Surface moisture under the residue will continue to evaporate slowly, but a number of days after the wetting event, the evaporation rate from the residue-covered surface can exceed that of the bare surface.

Methods and Materials

Experimental site

Field experiment was carried out during two *rabi* seasons in 2017-18 and 2018-19 at Indira Gandhi Agricultural University, research farm Raipur (C.G.) on "Influence of rice establishment method on Nutrient use efficiency and Water use efficiency in chickpea (*Cicer arietinum* L.) under rice-pulse cropping system in a Vertisols". The experimental site is situated in plains of Chhattisgarh at Eastern part of Raipur and it's located between 20º4º North latitude and 81º39º East longitudes with an altitude of 293 m above mean sea level.

Soil and climate

The soil of experimental site is represented as a typic chromesterts (Vertisols) (Arang-I series). It is locally called Kanhar. The most Vertisols fields are bunded and leveled. The soil is characterized by silty clay texture and moderate to slow internal drainage, medium to deep depth, and brownish gray in surface color, sub angular to angular, blocky structure and neutral in reaction. This region is dry moist, sub humid and the region receives 1200-1400 mm rainfall annually. The temperature during the summer months reaches as high as 48 °C and drop to 5 °C during December to January.

The experiment was laid out in a split-plot design with a total of twelve treatment combinations replicated three times. Main plot treatments were three rice establishment methods and the sub-plot treatments were four crop management options for chickpea. Three crop establishment methods include puddled transplanted rice (PTR), unpuddled transplanted rice (UTR) and direct seeded rice (DSR) whereas, crop management includes farmer's practice under rainfed (FPR), improved practice under rainfed (IPR), farmer's practice with lifesaving irrigation (FPLI) and improved practice with lifesaving irrigation (IPLI).In case of improved practice, chickpea was sown under conservation tillage (zero tillage + 30cm rice stubble) followed by recommended dose of fertilizers as basal dose and foliar application of 2% urea at flowering and 10 days after, whereas, under farmer's practice chickpea was sown under zero tillage without any rice residue, half dose of fertilizers and no foliar nutrition. The other practices were followed as per recommendation for this region. All data were analyzed by two-way analyses of variance (ANOVA) in a 3 x 4 split-plot design. The treatment means were compared using least significant differences for the main effects as well as their interactions at 5% level of significance (Gomez and Gomez 1984) [2].

Result and Discussion

Nutrient use efficiency in Chickpea

The data in respect of nitrogen, phosphorus and potassium use efficiency has been presented in table 1. It is evident from the data given in table that the nitrogen, phosphorus and potassium use efficiency in chickpea was recorded higher under direct seeded rice during both the years. The significantly lower nitrogen, phosphorus and potassium use efficiency was recorded with puddled transplanted rice during both the years.

It is also clear from the table that the nitrogen, phosphorus and potassium use efficiency, influenced significantly due to nutrient management practices during both the years of study. The crop grown under improved practice with lifesaving irrigation recorded the maximum nitrogen, phosphorus and potassium use efficiency followed by farmer's practice with lifesaving irrigation and rainfed improved practice and the lowest was recorded under rainfed farmer's practice for both the years. The interaction effect was found significant during both the years. Sharma *et al*., (2004) [12] the agronomic efficiency of N fertilizer applied to direct-seeded rice was comparable for the 2 years (18 and 24 kg grain per kg N applied). Direct-seeded rice had higher yield and accumulation of N following a post-rice legume than following fallow, but transplanted rice derived no such benefit from the legume. Fertilizer use efficiency in rainfed areas is comparatively lower than in irrigated agriculture, because of drought stress at critical growth stages. Phosphorus recovery in range of 1.6 to 13.3 percent has been reported in pot experiments using soybean as test crop (Jin *et al*., 2006) [3]. However, under field condition in irrigated area of Pakistan, P use efficiency has been reported to be in range of 5.2 to 25.7 percent for wheat and 3.9 to 21.3 percent for rice (Rehman, 2004). Sharma *et al*., (2005) [13] reported that the effect of rice establishment method on the performance of wet season rice (*Oryza sativa* L.) and post-rice crops of either chickpea or moong. The agronomic efficiency of N fertilizer applied to direct-seeded rice was comparable for the 2 years (18 and 24 kg grain per kg N applied). Direct-seeded rice had higher yield and accumulation of N following a post-rice legume than following fallow, but transplanted rice derived no such benefit from the legume.

Physiological efficiency of Nitrogen in Chickpea

The data in respect of physiological efficiency of nitrogen are presented in table 2. Physiological efficiency of nitrogen explained the additional yield for each additional kg of N uptake over control, which was significantly higher under direct seeded rice during both the years. The significantly lower physiological efficiency recorded under puddled transplanted rice during both the years. It is also clear from the table that the physiological efficiency of nitrogen, showed higher due to nutrient management practices during both the years of study. The crop grown under improved practice with lifesaving irrigation recorded maximum physiological efficiency followed by farmer's practice with lifesaving irrigation and rainfed improved practice and the lowest was recorded under rainfed farmer's practice for both the years. The interaction effect was found non-significant during both the years. Similar result found by Rahaman and Sinha (2013) [18], Kumar *et al*., (2011) [19] who also observed physiological efficiency of nutrients with increase in their application rate. Lower rates of S application resulted in higher nutrient recovery. Singh *et al.* (2011) [14], done experiment during 2003-04 and 2004-05 to evaluate the direct effect of phosphorus levels and their solubilizers on maize and residual effect on succeeding onion under rainfed temperate conditions of Kashmir valley.

Internal efficiency of N in Chickpea

The data in respect of internal efficiency of nitrogen presented in table 3. Internal efficiency of N explained the additional yield for each additional kg of N uptake over control, which was significantly higher under direct seeded rice during both the years. The significantly lower internal efficiency recorded under puddled transplanted rice during both the years.

It is also clear from the table that the internal efficiency, showed significantly difference due to nutrient management practices during both the years of study. The crop grown under improved practice with lifesaving irrigation recorded maximum internal efficiency followed by farmer's practice with lifesaving irrigation and rainfed improved practice and the lowest was recorded under rainfed farmer's practice for both the years. The interaction effect was found significant during both the years. Similar result found by Rahaman and Sinha (2013) [18], Kumar *et al*., (2011) [19] who also observed physiological efficiency, internal efficiency of nutrients with increase in their application rate. Lower rates of S application resulted in higher nutrient recovery. Singh *et al.* (2011) [14], conducted experiment during 2003-04 and 2004-05 to evaluate the direct effect of phosphorus levels and their solubilizers on maize and residual effect on succeeding onion under rainfed temperate conditions of Kashmir valley. Direct application of P to maize recorded higher use efficiency and lower apparent recovery of P whereas higher apparent P recovery and lower P use efficiency.

Apparent nitrogen recovery or Recovery Efficiency in Chickpea

The data in respect of apparent nitrogen recovery or recovery efficiency in chickpea presented in table 4. Internal efficiency of N explained the additional yield for each additional kg of N uptake over control, which was significantly higher under direct seeded rice during both the years. The significantly lower apparent nitrogen recovery or recovery efficiency in chickpea recorded under puddled transplanted rice during both the years.

It is also clear from the table that the apparent nitrogen recovery or recovery efficiency in chickpea, showed significantly difference due to nutrient management practices during both the years of study. The crop grown under improved practice with lifesaving irrigation recorded the maximum apparent nitrogen recovery or recovery efficiency in chickpea followed by farmer's practice with lifesaving irrigation and rainfed improved practice and lower was recorded under rainfed farmer's practice for both the years. The interaction effect was found significant during both the years. Similar result found by Rahaman and Sinha (2013) [18], Kumar *et al*., (2011) [19] who also observed physiological efficiency, internal efficiency of nutrients with increase in their application rate. Lower rates of S application resulted in higher nutrient recovery. Singh *et al.* (2011) [14], conducted experiment during 2003-04 and 2004-05 to evaluate the direct effect of phosphorus levels and their solubilizers on maize and residual effect on succeeding onion under rainfed temperate conditions of Kashmir valley.

Partial factor productivity of nitrogen and phosphorus in Chickpea

The data in respect of partial factor productivity of nitrogen and phosphorus in chickpea presented in Table 5. Internal efficiency of N explained the additional yield for each additional kg of N uptake over control, which was significantly higher under direct seeded rice during both the years. The significantly lower partial factor productivity of nitrogen and phosphorus in chickpea recorded under puddled transplanted rice during both the years.

It is also clear from the table that the partial factor productivity of nitrogen and phosphorus in chickpea, showed significantly difference due to nutrient management practices during both the years of study. The crop grown under improved practice with lifesaving irrigation recorded maximum internal efficiency followed by farmer's practice with lifesaving irrigation and rainfed improved practice and the lowest was recorded under rainfed farmer's practice for both the years. The interaction effect was found significant during both the years. Similar result found by Rahaman and Sinha (2013) [18], Kumar *et al*., (2012) [6] who also observed physiological efficiency, internal efficiency, Partial factor productivity of nitrogen and phosphorus in Chickpea of nutrients with increase in their application rate. Lower rates of S application resulted in higher nutrient recovery. Singh *et al.* (2011) [11], done experiment during 2003-04 and 2004-05 to evaluate the direct effect of phosphorus levels and their solubilizers on maize and residual effect on succeeding onion under rainfed temperate conditions of Kashmir valley.

Water use efficiency in Chickpea

The data in respect of water use efficiency presented in table 6. Water use efficiency was recorded significantly higher under direct seeded rice during both the years. The significantly lower water use efficiency recorded was puddled transplanted rice during both the years.

It is also clear from the table that the water use efficiency was influenced significantly due to nutrient management practices during both the years of study. The crop grown under improved practice with lifesaving irrigation observed the maximum water use efficiency followed by farmer's practice with lifesaving irrigation and rainfed improved practice lowest water use efficiency was recorded under rainfed farmer's practice for both the years. The interaction effect was found significant during both the years. Mohammad *et al*., (2011) [20] determine the effect of tillage system on moisture content, water use efficiency and yield on wheat and oat. These results indicated that tillage had slightly improved the WUE as compared to no tillage treatment. Although similar moisture content in 0-30 cm upper soil was recorded in the tillage and no-tillage treatments at all growth stages. Patel *et al*., (2008) [9] a field experiment was conducted during summer 2003 and 2004. The water use efficiency and pod yield over the schedules of 50 and 60 mm CPE. Improved water efficiency for cropping system in semiarid arias to characterized soil water extraction profile across rooting zones for various pulse crops. Pulse plants extracted about 4 mm of water from the top 30 cm layer and extracted little to non below 30 cm soil depth. Chickpea the lowest water use efficiency Wang *et al*., (2009) [17]. Joshi *et al*., (2013) [4] the review paper resulted that direct seeded rice (DSR) technique is becoming popular nowadays because of its low-input demanding nature. It involves sowing pre-germinated seeds into a puddled soil surface (wet seeding), standing water (water seeding) or dry seeding into a prepared seedbed (dry seeding) water use efficiency (WUE) and productivity may increase if appropriate leveling of lands is done. Early crop vigour, short stature and short duration may also improve WUE. Wanga *et al*., 2016 [21] to study investigated if and how irrigation regimes could synergistically interact with nitrogen (N) rates to increase grain yield, water use efficiency (WUE) and N use efficiency (NUE) in rice.

Conclusion

The direct seeded rice proved to be better than puddled transplanted rice, with respect to post rice crop, nutrient use efficiency, physiological efficiency, internal efficiency, apparent recovery or recovery efficiency and partial factor productivity of nitrogen and phosphorus and potassium during both the years. The rice establishment methods affected water use efficiency significantly during both the year *rabi*, 2017-18 and 2018-19 and the direct seeded rice performed better and found statistically superior than pudduled transplanted rice. Among the water and nutrient management practices, the improved practices with lifesaving irrigation gave higher water use efficiency.

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