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Review Article

EFFECT OF APPROPRIATE TECHNOLOGY TO ENHANCE THE PRODUCTION OF FIELD CROPS IN ABERRATED CLIMATIC REGIME AND RESOURCE MANAGEMENT

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Abstract: Aberrated climatic regime is the major causes of reduction in food production in the Kymore Plateau & Satpura hills zones of Madhya Pradesh. The Panna district falls under Bundelkhand as well as Kymore Plateau and Satpura hills agro climatic regions where the average annual rainfall is about 1176 mm and only 48% cultivated area is irrigated and generally the agriculture is rainfed farming. The total amount of average rainfall in these regions may be adequate to meet the water requirements of the crops and cropping systems. But the climate change since last two decades has brought out the changes in rainfall pattern and distribution which exhibited aberrations either as sudden downpour or long dry spells during kharif season that poses severe stress on crop and reducing their grain yield and degradation of natural resource. In view of this, *in-situ* rain water management strategies for minimizing risk of crop failure and stabilizing crop production. In this regard, Krishi Vigyan Kendra Panna have develop modules and demonstrated on farmers field *i.e.*, Sowing with broad bed furrow system, sowing with furrow irrigated raised bed planting, sowing with sweep seed rill, *in-situ* mulching of weeds in Pigeon pea crop, Direct Seeded Rice, zero-tillage, crop diversification, Intercropping and weed management which allow maximum utilization of given or available resources and draining of the excess water and conserve the *in-situ* soil moisture under less precipitation regime through increased infiltration rate and reduced run-off. Therefore, an integrated resources management approach comprising *in-situ* water conservation, harvesting of excess water in ponds and groundwater recharging and its efficient use through appropriate supplemental irrigation methods, improved crop varieties and cropping systems, balanced nutrition of crops, crop diversification and intensification with high value crops and crop protection is needed to produce more food and income per unit area under limited irrigation/ rain fed situation. Which is beneficial in enhancing crop productivity and rainfall use efficiency by implementing improved technologies by farmers community in District-Panna.

Keywords: Enhance crops production, appropriate technology and natural resource management

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Introduction

Rainfed agriculture occupies 68% of India's cultivated area and supports 40% of the human and 60% of the livestock population. However, aberrant behaviour of monsoon rainfall, eroded and degraded soils with multiple nutrient and water deficiencies, declining ground water table and poor resource base of the farmers are principle constraints for low and unstable yields in rain fed areas[1]. Increasing crop productivity to meet food requirements of teaming millions in our country poses a greater challenge. In this context, there is a need to enhance the productivity of rain fed crops from at least 1 to 2 t/ha. To meet the food requirements by 2020 AD. But Erratic rainfall results in widely low production, leading to production deficit and causing land degradation through soil erosion and water deficiencies and decline groundwater table and poor resources base of the farmers are principle constraints for low productivity and unstable yields in rainfed areas [1,2]. Population growth accompanied by increased demand for natural resources to produce food and to meet needs of the other sectors of the economy, further exacerbates the existing problems. Thus, a process of progressive degradation of resources sets in which intensives with every drought and the period following it. If not checked timely and effectively, it leads to permanent damage manifested as loss of biodiversity and degradation of natural resources [3]. Unless the nexus between drought, land degradation and poverty is addressed, improving the livelihoods that are dependant mainly upon natural resources can be farfetched. Water is the key factor and through efficient and sustainable management of water resources, entry could be made to break the nexus [3].This paper describes an integrated resource management approach adopted by Krishi Vigyan Kendra to enhance the goal of increasing crop production and improving rural livelihoods through sustainable and efficient use of given or available resources in rain-fed areas of District – Panna of Madhya Pradesh.

Appropriate technology for Enhancing production and resource management:

Krishi Vigyan Kendra Panna has adopted an integrated natural resource management approach to enhance agricultural productivity/unit area under rain-fed situation, which isa powerful integrative strategy of enhancing agricultural production and productivity. KVK has learnt that converging on sowing with broad bed furrow system, Sweep seed drill, Furrow Irrigated Raised bed planting, *in-situ* mulching of weeds in Pigeon pea crop, Direct Seeded Rice, Crop diversification, Intercropping and weed management. This was achieved through adoption of integrated resource management approach, which is holistic in nature to achieve the desired goals of enhancing the production and productivity of field crops, reducing land degradation and protecting the environment, which ultimately results in increased economic benefit to rural communities to alleviate poverty. The contribution of both individual and combined effects of improved technologies on productivity enhancement and water use efficiency is presented here.

***In-situ* Soil and Water Conservation by BBF and FIRBS**:
Implementation of the type of land and water management system depends on the characteristics of the soil, climate, farm size, capital and availability of human and power resources. Land smoothening and forming field drains are basic component of land and water management for conserving and safe removal of excess water. Broad-bed furrow (BBF) and Furrow Irrigated Raised Bed Planting system is an improved *in-situ* soil and water conservation and drainage technology for the soil. The system consists of relatively at bed approximately 100 and 60 cm wide and shallow furrow about 50 and 30 cm wide laid out in the field BBF& FIRBS system helps for safe disposal of excess water through furrows when there is high intensity rainfall with minimum soil erosion, while at the same time it serves as land surface treatment for *in-situ* moisture conservation. The system helps to reduce the velocity of runoff by impounding water in series of depressions and thus decrease the chance of developing rills in the fields. And series of dead furrows across the slope at 3-5 m intervals, where the size of furrows is about 20 cm wide and 15 cm deep [4 & 5] reported that maximum average seed yield of soybean was recorded in 6 m wide raised bed followed by 9 m raised bed and minimum in flat plots. Besides providing adequate surface drainage to soybean crop, the land configurations were also useful during prolonged dry spell there by, minimizing any adverse effect of soil moisture stress at flowering and seed development stages of rainy season crops. Post rainy seasons crops were successfully grown with successfully high yields with higher gross and net returns. On-farm trials on land management of KVK farm land revealed that BBF system resulted in 35 percent yield increase in soybean during rainy season and yield advantage of 21 percent in chickpea during post rainy season when compared with the farmers practice [6 & 7]. Similar yield advantage was recorded in maize and wheat rotation under BBF system. Yield advantage of 15 to 20 percent was recorded in maize, soybean and groundnut with conservation furrows on soils over farmers' practices of District- Panna. Yield advantage in terms of rainfall use efficiency (RUE) were also rejected in traditional cropping system Soybean-Chickpea, Paddy-Wheat and Fallow -Chickpeaby adopting new cropping system Soybean-Mustard, Paddy-chickpea, inter cropping Soybean: Maize (4:2) and Soybean: Pigeon pea (4:2) and Fallow-Early mustard- late Chickpea/Wheat under improved land management systems [8].

Effect of BBF and FIRBs on growth attributes:
Soybean sown on ridges resulted in greater emergence of seedling (77.3%), followed by BBF the seed (72.7%), while seed broadcasting resulted in a lower emergence of seedlings (59.0%). A higher percentage of germination in ridge and furrow planter or BBF method due to appropriate cover soybean/greengram/blackgram seed in soil bed allow moisture and oxygen to approach the seeds under the covered soil and less distribution is justified and faster drying ridge and sensitivity seed oil (soybean) to high temperature and moisture is justified that these results match with research. Whenever normal planting results 20-25 % and 7-13% uncovered seeds in broad casting and flat sowing which normally do not aid to plant stand [9]. The above results demonstrate that ridge sowing displayed greater plant height as compared to broad bed furrow and broadcasting methods. The result of moisture content shows that soil moisture content was conserved more in ridge plot as compared to other treatments, it is conducted that soil inverted by moldboard plough plus disc harrow plus ridger is more suitable for the conservation of high soil moisture content. The reason may be that in ridge plot more water holding capacity due to high looseness of soil particles. The present result is supported that ridge tillage the moisture content greater than in the ploughed treatment [10]. The maximum value of Leaf area index at 60 DAS was associated with ridge and furrow or BBF method was found significantly superior in soybean, pigeon pea, blackgram10-35%. Due to prolonged period of moisture supply of all growth stage increases the leaf area of the crop; enable it to intercept most of the incoming radiation by photosynthetic organ, conversion of the intercepted radiation in to dry matter and more portioning of that dry matter into economic grain yield and consequently the final maximum dry matter production was noted in this method. Imbalance availability of moisture during any growth stage low production of biomass due to competition for moisture and significantly reduced profit compared to properly moisturized crop[7]. The results on main and associated lateral root length of soybean/green gram/black gram recorded at 60 DAS were recorded highest as compared to line sowing and broad casting. It may be seen from the results that varied significantly between the treatments. Soybean sown on ridges/BBF resulted in greater of main and associated lateral root length (22-33 %), followed by broad bed furrow (21-29%), while seed flat sown and broadcasting resulted in lower length of root respectively. Due to roots found favorable conditions in soil structure was well preserved, ensured aeration and moisture [11,12]. While reduce tap and associated lateral root length due to compact soil structure under submerge situation. Because root previously established below the soil surface in submerge damage from the effect of submerge situation. Shoot growth also exhibits symptoms of submerge, primarily seen as checked leaf expansion rates and sometimes a slight inhibition of photo synthesis. The nitrogen and carbon economy of plants is severely disrupted after flooding or moisture stress. Nitrogen uptake is impaired presumably through death of much of the existing root system and denitrification removing available nitrate form soil its due to transient yellowing of leaves [13]. Ridge and furrow planting revealed its supersite in production of nodules (61.5/plant) and their diameter at 60 DAS (6.5 mm/nodule) fallowed by broad bed planting with 4 rows (60/plant and 6.0 mm/nodule) and lowest recorded in flat planting and broad costing 58 and 56 / plant, 5.0 mm/nodule of soybean. These planting methods are required not only to conserve moisture for plant growth but also to drain out excess water without causing erosion. In such aerobic surface soil become strong sinks for nitrogen and carbon as fibrous secondary roots develop and rhizobia infect these roots to form nodule. There is also extensive growth of thin-walled aerenchyma tissue from lenticels on the surface of roots and nodules adding gaseous exchange and reduced the oxygen stress resulted increase nodule number and their diameter [1 & 14].

Available soil moisture dynamics under BBF and FIRBS
The effect of broad bed furrow system and furrow irrigated raised bed planting system at depth15 cm on soil surface evaporation was determined from soil sample. The control plot contained broad casting. The sample were weighed every five days interval to determine the percentage water loss through volumetric methods. The result was indicated that maximum soil moisture retention percentage in root zone under FIRBS and BBF (100 to 49 %) and (100 to 28 %) as compared to broad casting sowing methods (100 to 21%). Irrespective of BBF treatments recorded higher soil moisture mainly due to greater infiltration by reduced runoff and subsequent arresting the evaporation of the infiltrated water and reduced weed growth apparently contributes to soil moisture gains. In situ mulch of weed have conserved the rainwater through reduced runoff loss, increased infiltration and ameliorating of soil temperatures [15]. In situ mulching of weeds recorded more soil moisture in entire life of crop than manual weeding because no mulching where the rainfall could be lost as runoff and more evaporation from soil surface [16]. The no mulching practice of moisture conservation registered lower soil moisture during the cropping period mainly because of sealing of surface by falling rains resulted in more runoff loss and less infiltration.

Resource conservation through Modified Seed drill
The results clearly revealed that sowing method affects the growth and yield of soybean crop. Maximum growth and yield of soybean crop was recorded from modified seed drill sown crop than the broadcasting sown crop [11]. The growth parameters such as plant height, number and size of nodules per plant were recorded higher from modified seed drill sown crop than the broadcasting. Because soybean crop sown with modified seed drill is attributed to appropriate cover of seeds by well pulverized soil that allow abundant quantity of moisture and oxygen to the seeds for proper germination and growth of seedlings. This sowing method not only conserves the soil moisture for plant growth but also drain out the excess water without causing soil erosion. In addition, the furrow act as *in-situ* soil moisture conservation hence mitigates the detrimental effects of dry spell to the crop [17]. As the plants get almost equal chance for nutrient and moisture absorption for their growth which results in uniform growth of plants that leads

greater seed size which contributed higher yields and higher income similar result was found in corn grain yield by 60–95 percent in drought and average years, 70-90 percent in wet years and 20–30 percent in very wet years [11]. Therefore, maximum crop growth and grain yield of soybean was obtained where seeds were sown with modified seed drill as compared to broadcasting method. This sowing method not only conserves the soil moisture for plant growth but also drain out the excess water without causing soil erosion. In such aerobic conditions, the soil act as strong sinks for nitrogen and carbon for the development of fibrous secondary roots and Rhizobium bacteria that infect these roots to form nodules. There is also extensive growth of thin-walled aerenchymatous tissues from lenticels on the surface of roots adding gaseous exchange and reduced the oxygen stress that leads increased nodule numbers and their size. The favorable growth responses may be accounted due to reduced oxygen stress, better nutrient acquisition and favorable physical environment for crop growth and pod filling by saving the soil moisture for prolong period through increased infiltration rate of rain fall and reduced runoff [18]. Thus, the furrow act as *in-situ* soil moisture conservation and mitigates the detrimental effects of dry spell to the crop. As the plants get almost equal chance for nutrient and moisture absorption which results in uniform growth of plants that leads greater seed size and higher yields. Therefore, maximum crop growth and grain yield of soybean was obtained from modified seed drill sown crop than the broadcasting.

Weed density

The use of developed modified seed drills is known as weep seed drill led to significantly lower weed count as compared to use of normal seed drill at 15 days after sowing soybean during all the three years of experimentation. The reduction in weed population ranged from 59.91% to 68.37% with a mean value of 64.65%. This can be explained as the sweeps attached to developed seed drill could destroy emerging weeds and exposed the weed seeds during sowing operation. It has been reported that first 40–45 days are crucial for weed management to optimize yields [19]. Low seed yield due to infestation of weeds hindering the uptake of nutrients and reducing photosynthesis by shading of the main crop. yield and N uptake in maize were negatively correlated with that of weeds. Elimination of weeds during early stages of crop growth had been thereby [20].

Furrow Irrigated Raised Bed Planting System

Furrow Irrigated Raised Bed Planting System technology contributes in increasing soybean/Chickpa/Wheat yield and also helps in reducing cost of production. The results show a convincing as far as economic superiority of Furrow Irrigated Raised Bed Planting technique over conventional method of sowing. Furrow Irrigated Raised Bed planting technology is very conducive in increasing the crop production and net income. Grain yield of maize was grater with Ridge and furrow which was attributed to the greater amount of available Nitrogen under this system [21]. Because reduced contact area of water on land surface thereby reducing crusting of soil and evaporation losses. Suitable land configurations help in enhancing the time of concentration, absorption and storage of water, thus useful for the crops [22]. Similar result was found bynew method of ridge and furrow rainwater harvesting significantly increased potato tuber yield. The ridge plays an important role in harvesting rainwater while the furrow provides a planting belt that not only receives rainfall over its surface, but also accepts by water from the ridge's runoff [10]. Other benefits which FIRBS technology provides are in reducing the need for applying herbicides, controlling erosion, reducing the amount of N that "leaks" into the environment, providing environmentally friendly options for managing crop residues, reducing soil compaction and bettering soil physical structure over time [23]. Therefore its popularity would increase day by day among the farming community and area under such technologies is expected to enhance widely in rain fed. The suitable policies are needed in order to further facilitate promotion of Furrow Irrigated Raised Bed Planting technology by encouraging private sector-public sector cooperation and educating farmers about the use of this technology. The long-term impacts of this technology on food production, natural resources (land and water) and linkages with poverty alleviation should be further explored. The participatory research at farmers' field could play pivotal role in technology improvements and dissemination.

Weed density

Appropriate method of sowing has several advantages like better inter-culturing, weeding, uniform irrigation, management of insect, pest and disease and mechanical harvesting. Ridge sowing is considered to be the methods which have the above advantages, against the other methods of sowing like drilling and broadcasting of seed. Weed control by inter-culturing, excess moisture removed and reduction of surface run off by increase in infiltration [24]. Also the loose and porous heap under ridges and furrows was found to provide better aeration, microbial activity and drainage which gave increased individual plant yield and per hectare yield as compared to other methods [22].

Available soil moisture dynamics

Among the different in situ soil moisture conservation techniques, Furrow irrigated raised bed technique conserved 13,17,20 and 23 % more soil moisture over broad casting and flat sowing methods at each 5 days intervals of soybean crop respectively. While 5, 7, 8, and 9 % more moisture conservation was found under Furrow irrigated raised bed sowing technique respectively than Broad bed furrow irrigated sowing methods at each 5 days intervals of soybean crop. Irrespective of ridges and furrows treatments recorded higher soil moisture mainly due to greater infiltration by reduced runoff and subsequent arresting the evaporation of the infiltrated water and reduced weed growth apparently contributes to soil moisture gains. Ridges and furrows have conserved the rainwater through reduced runoff loss, increased infiltration over traditional practice of moisture conservation [10]. Ridge and furrow technique recorded more soil moisture at each observation than traditional sowing methods because where the rainfall could be lost as runoff. The traditional sowing practice (Broad casting and flat sowing) of moisture conservation registered lower soil moisture during the cropping period mainly because of sealing of surface by falling rains resulted in more runoff loss and less infiltration.

Crop yield and resource conservation by Zero-Tillage

Experiences from several locations in the Indo-Gangetic plains showed that with zero tillage technology farmers were able to save on land preparation costs by about Rs. 2,500 per ha and reduce diesel consumption by 50 – 60 liters per ha [25]. Zero tillage allows timely sowing of wheat, enables uniform drilling of seed, improves fertilizer use-efficiency, saves water and increases yield up to 20%. This has resulted in savings in irrigation water, improved fertilizer use and reduced soil crusting.The focus of developing and promoting conservation technologies has been on zero-till seed-cum fertilizer drill for sowing of wheat in rice-wheat system. It has been reported that the area planted with wheat adopting the zero-till drill has been increasing rapidly and presently 25% – 30% of wheat is zero-tilled in rice-wheat growing areas of the Indo-Gangatic plains of India [26]. Adoption of Zero-tillage in wheat cultivation reduction in cost of production by Rs 2,000 to 3,000 ha^{-1}, enhancement of soil quality, i.e. soil physical, chemical and biological conditions [27] enhancement, in the long term C sequestration and build-up in soil organic matter constitute a practical strategy to mitigate greenhouse gas emissions and impart greater resilience to production systems to climate change related aberrations, reduction of the incidence of weeds, such as Phalaris minor in wheat, enhancement of water and nutrient use efficiency, enhancement of production and productivity (4%-10%) [27]. Avoiding crop residue burning reduces loss of nutrients, and environmental pollution, which reduces a serious health hazard [28].

Crop yield and resource conservation by *In-situ* mulching of Weeds

It is clearly evident from the results that maximum yield attributed i.e. No. of pods /plant, fruits set (%), test weight and higher yield was obtained from *In-situ* mulching (respectively followed by hand weeding respectively as compared to control plot. It may be attributed to increase in number of flowers per plant, number of pods per plant, higher percentage of fruit setting and test weight due to availability of soil moisture at critical stage of crop growth on account of *In-situ* mulching of weeds. Mulch might have enhanced microbial activities due to favorable soil temperature and soil moisture conditions in the rhizosphere of pigeon pea resulting in quick release of nutrient and their uptake which ultimately increased pod yield of pigeon pea [29].

The treatments of mulching resulted in moderation the soil temperature during rainy season in rain fed situation in pigeon pea crop and which increased grain yield [30]. The effect of in situ mulch of weeds on soil surface evaporation was determined from soil sample. The control plot contained no mulching. The sample were weighed every five days interval to determine the percentage water loss through volumetric methods. The result was indicated that maximum soil moisture retention percentage in root zone under In situ mulching of weeds (100,65,55,52 and 49 %) respectively followed by manual weeding of pigeon pea (100,56,42,33 and 28) as compared to No. mulching of weeds (100,50,38,31 and 21). Irrespective of In situ, mulching treatments recorded higher soil moisture mainly due to greater infiltration by reduced runoff and subsequent arresting the evaporation of the infiltrated water and reduced weed growth apparently contributes to soil moisture gains. In situ mulch of weed have conserved the rainwater through reduced runoff loss, increased infiltration and ameliorating of soil temperatures [31]. *In situ* mulching of weeds recorded more soil moisture in entire life of crop than manual weeding because no mulching where the rainfall could be lost as runoff and more evaporation from soil surface [16]. The no mulching practice of moisture conservation registered lower soil moisture during the cropping period mainly because of sealing of surface by falling rains resulted in more runoff loss and less infiltration. Because higher uptake of nutrients under mulched condition in pigeon pea has resulted from higher availability of soil nutrient of NPK. This might be attributed to increase of soil temperature resulting in higher microbial activity greater decomposition of organic matter present in the soil in the first phase and then due to decomposition of perished microbes when soil temperature increased beyond the critical limit [32].

Nodule Parameter

Higher root nodulation and their diameter and dry weight was found under in situ mulching of weeds. And increased their diameter and dry weight was directly related to more assimilation atmospheric nitrogen in the presence of optimum soil moisture and temperature Favourable soil physical environment was provided by the mulches. Live weed mulches did not allow the radiant energy to contact the soil directly. And the radiation interception due shading and evaporative cooling were responsible to shading and evaporating cooling was responsible for lower soil temperature [1 & 14].

Weed control

Finally, *In-situ* mulch can enhance crop growth and competitiveness against weeds by conserving soil moisture and moderating soil temperature [33]. Significantly reduced weed intensity in soybean crop [31].

Available soil moisture dynamics under Mulching

The result was indicated that maximum soil moisture retention percentage in root zone under In situ mulching of weeds (100,65,55,52 and 49) respectively followed by manual weeding of pigeon pea (100,56,42,33 and 28) as compared to No. mulching of weeds (100,50,38,31 and 21). Irrespective of In situ, mulching treatments recorded higher soil moisture mainly due to greater infiltration by reduced runoff and subsequent arresting the evaporation of the infiltrated water and reduced weed growth apparently contributes to soil moisture gains. In situ mulch of weed have conserved the rainwater through reduced runoff loss, increased infiltration and ameliorating of soil temperatures [34]. In situ mulching of weeds recorded more soil moisture in entire life of crop than manual weeding because no mulching where the rainfall could be lost as runoff and more evaporation from soil surface [16]. The no mulching practice of moisture conservation registered lower soil moisture during the cropping period mainly because of sealing of surface by falling rains resulted in more runoff loss and less infiltration.

Resource Conservation by Inter cropping

Land equivalent ratio

LER of soybean + maize intercropping system was recorded as 1.4 which clearly showed 40 percent increment in yield or to get same level of yield from sole crop, 1.4 ha area would be required. Other workers have also reported LER greater than 1 in soybean: maize intercropping system [35]. The higher productivity of the intercropping system may be attributed to complementary and efficient use of available resources by the component crops [36]. In maize + pigeon pea intercropping system, dry matter production per unit of photosynthetic active radiation (PAR) absorbed was higher than the sole crops [37]. The higher PAR conversion efficiencies under intercropping systems may be attributed to greater spread and distribution of light over leaf area of intercrop canopies during early stage of growth [38].

Production efficiency

The higher production efficiency was obtained under soybean + maize intercropping (373.1 %) than sole cropping system. The superior production efficiency from soybean + maize intercropping could be due to spatial and temporal advantages as compared to sole cropping system [35 & 36].

Total system productivity

Maize and soybean cultivars 'HQPM-1' and 'JS-9305' recorded highest grain yield under both cropping system as compared to existing cultivars 'Satha' and 'JS-335' and contributed to higher total system productivity (6,718 kg/ha) under intercropping system. This might be accredited to lesser competition, temporal complementarities and better utilization of resources by the component crops having differential rooting pattern, canopy distribution and nutrient requirements [35].

Diversified crop rotations/Intercropping

The rotation/intercrop of crops is not only necessary to offer a diverse "diet" to the soil micro-organisms, but also for exploring different soil layers for nutrients that have been leached to deeper layers that can be "recycled" by the crops in rotation. Furthermore, a diversity of crops in rotation leads to a diverse soil flora and fauna. Cropping sequence and rotations involving legumes helps in minimal rates of build-up of population of pest species, through life cycle disruption, biological nitrogen fixation, control of off-site pollution and enhancing biodiversity [39].

Resource conservation through Direct seeded Rice

The present production trend showed decline in productivity, mostly because of heavy infestation of weeds, imbalanced use of fertilizers and pesticides, over-exploitation of the natural resources, particularly water, deterioration in physical conditions of the soil and emergence of new bio-types of pests and diseases. These led to yield stagnation, causing concern about the future potential for productivity growth and long-term sustainability. Thus, the major challenge before the researcher is to innovate appropriate technologies to produce more food from diminished land resources for the burgeoning population pressure and to improve as well as conserve the natural resources [40].

Resource conservation through SRI Technique

KVK Panna and others NGOs have introduces System of Rice Intensification along with short duration hybrid variety JRH-5. Because everybody believes that rice is an aquatic plant and grows best in standing water. While Rice is not an aquatic plant it can survive in water but does not survive in reduced oxygen (hypoxic) levels [41]. Because rice plants expend lot of its energy to develop air pockets (aerenchyma tissue) for protection their own life against the water logging. Therefore, under SRI paddy field are not flooded but kept moisture during vegetative phase and only one inch water is maintained at panicle initiation to grain filling stage [41]. Because at this stage nearly 70 percent of rice root tips was degenerated for more uptake of moisture and nutrient. Thus it is beneficial for small and marginal farmers. Prior to the 1950s, direct seeding was most common, but was gradually replaced by puddled transplanting by traditional or SRI technique [42]. In Asia, rice is commonly grown by transplanting 12-14 days old seedlings into puddled and continuously wet and dry of soil (land preparation with wet tillage). The advantages of the traditional transplanted puddled rice (TPR) system of crop establishment include increased nutrient availability (e.g. iron, zinc, phosphorus), weed suppression [43] easy seedling establishment, and creating anaerobic conditions to enhance nutrient availability.

The transplanted puddled rice, leads to higher losses of water through puddling, surface evaporation and percolation. Repeated puddling adversely affects soil physical properties by dismantling soil aggregates, reducing permeability in subsurface layers, and forming hard-pans at shallow depths, all of which can negatively affect the following non-rice upland crop in rotation. SRI is a planting method based on the principles of using single seedling at 8-14 days seedling at wide spacing between row to plant (25 x 25 cm), the application of compost, mechanical weed control and intermittent irrigation at cracking of soil surface in the rice field. While farmers was transplanted 3-4 seedling/hills at 35-40 days seedlings closer spaced clumps of plants between row to plant (15 x 10 cm) under exiting practices. And farmers are generally use their own seeds without treated and use of imbalance dose of fertilizers, mechanical weeding are not under practice. SRI replaces the traditional practice of flooding paddy field with limited, intermittent water application. This uses much less water, making rice production possible where there is insufficient water to keep fields flooded. For weed control through use a simple mechanical weeding tool which removes weeds and aerates surface soil by hoeing and weeding should be done by cono-weeder to loosen the soil and to make the paddy field free from weed [44].The loosening of soil results in better aeration for the root zone and increases the root length by letting them take more moisture & nutrient from the soil. This helps in bringing forth more tillers in the plant with more vigor compost, manure or other organic materials are applied as the base for fertilization, improving soil structure, soil organic matter content and fertility. If necessary, chemical fertilizers may be used as a supplement. But farmers are not adopted broadly of SRI Technique in paddy cultivation. Because more labor consume under square transplanting and mechanical weeding, and required of skilled labor, low input use efficiency (either given or available resources), compost manure is required but there are not easily available, mechanical weeding is not possible in without row and plant arrangement.

Resource conservation through Crop diversification

Crop diversification can be a useful means to increase crop output under different situations. They can be approached in two ways, horizontal crop diversification and vertical crop diversification. The addition/replacement of one or more crops from the existing cropping system, which is referred as horizontal diversification. This type of crop diversification means the broadening of the base of the system, simply by adding/rotate more crops to the existing cropping system utilizing techniques such as multiple cropping techniques coupled with other efficient management practices. The systems of multiple cropping have been able to increase food production potential and increase of the cropping intensity.And vertical crop diversification, in which various other downstream activities are undertaken. This could be illustrated by using any crop species, which could be refined to manufactured products, such as fruits/vegetables, which are canned or manufactured into juices or syrups as the case may be. Vertical crop diversification will reflect the extent and stage of industrialization of the crop. ". It is necessary to indicate here that crop substitution and adjustment are linked to the main concept of crop diversification and are strategies often used to maximize profit of growing varieties of crops.

Crop diversification:-

Chickpea (*Cicer aritinum*.) is an important economic leguminous pulse crop and considered as a good source of protein for human being. Chickpea has been a predominant crop in Madhya Pradesh especially in Panna district which accounts for 64% area under chickpea cultivation during *Rabi* Season. The district Panna are geographically suited lies between 23º, 45' N and 25º , 10' N latitudes and 75º ,45' E and 80º , 40' E longitudes. Paddy/ Soybean/fallow – gram are a predominant cropping system adopted in this region which leads establishment of harmful dominated weeds flora such as *Vacia sativa* during *Rabi* season which significantly reduces the yield of Chicpea. Density of *Vacia sativa* was being observed 180-200/m^2) they similarly compete with the chick pea crop for soil moisture, space, sunlight and nutrients and affects its growth as chick pea is slow growing crop and having lesser leaf area. Thus, yield and dry matter production is reducing in a linear pattern which is proportional to the length of time where *Vacia sativa* compete with chick pea crop. Though control of weeds, insect and pest infestation is possible by use of corps diversification. Under such circumstances, it is advised to change either the crop rotation or inclusion of short duration crop as an inter crop. The practice of croprotation/intercropping explore efficient utilization of all given and available resources, which maintain stability in production and obtain higher net return accordingly which is not possible through sole cropping system [45]. In view of this, Replace of Chickpea by wheat/linseed as a sole crop were investigated to break monotomy cropping system for maximization of yields and net return in Panna district of M.P. because any selective herbicide is not event for control of *Vacia sativa* (Akari) in chickpea crop. Because *Vacia sativa* and chickpea belonging to same family leguminous. In this places rotate the crop by wheat/Linseed for control of dominated weed flora through highly selective herbicide Metsufuron @ 20 g a.i./ha at 20-25 DAS. Metsufuron inhibit the process of cell division of meristemtic tissues as a result of which food reserves of treated plants are used up rapidly, causing growth relatively slow and their killing process start and weeds dried rapidly [46].

Resource Conservation Through weed management

Weeds represent one of the major resource consuming and limiting factor in soybean production and causes substantial qualitative and quantitative losses in crop yield which may ranges from 31- 84% [47]. Degree of losses in crop yield depends on the type of weed flora, their density and duration of competition for nutrient, water, light and space. In such situation manual and mechanical weeding are effective but costly time consuming and many a time has not possible to unfavorable weather conditions particularly *Kharif* season and less availability of labour. Under such circumstances chemical control forms single most important weed management practices. Herbicides have come as a welcome alternative for manual or mechanical weeding which for more efficient less labour intensive and often more cost effective then other methods of control. But generally use of inappropriate weedicide their doses, time and method of application make them less effective due to lack of knowledge. Among these, no use of appropriate surfactant its due to less effective control of weed and reduce the crop yield in *Kharif* season. While, no use of surfactant have shown that the spray droplets slightly retained on the leaf surface and the majority of those droplets bounce off the leaf surface [48]. Therefore, improvement in the retention capacity of droplets with surfactant could be an approach to increase the herbicide performance and to reduce its dosage. During this process led to reducing the contact angle and more spread of droplets on the leaf surface. Indeed, surfactants are an acceptable compound to enhance the penet*rabi*lity of herbicide active ingredient in order to improve performance of weedicide for controlling a weed [48]. Therefore, all these points were undertaken for chemical weed management in crop cultivation. In order to curb the aforesaid problem a comprehensive trials on weed management in Chickpea, Wheat, Paddy and soybean was conducted. The required quantity of herbicide should be mixed in 500 litres water & surfactant @ 1250 ml/ha and sprayed uniformly in each plot with knapsack back sprayed by using flat fan or cut Z nozzle. A numbers of herbicide have been tested for effective weed control and increase Chickpea, Wheat, Paddy, soybean yield and benefit cost ratio.

Resource conservation through Improved Crop Varieties and Cropping Systems

The adoption of improved varieties always generates significant field level impact on crop yield and stability. The yield advantage through the adoption of improved varieties has been recognized undoubtedly in farmer participatory trials across Panna district under rain-fed systems. Recent trials was conducted on varietal performance on mustard/chickpea/field pea/lentil/wheat/paddy revealed that mean yield advantage of 15 to 52 percent respectively was achieved with high yielding varieties like Pusa Agrani,JG-16,JG-322,JG-11,Prakas,PKL-5,GW-3269,JW-3211 and JRH-5as compared with use of local varieties and farmers' management. These results showed the efficient use of given /available resources by the improved varieties reflected in grain yields under given situations. However, yield advantage of above was reported in mustard/chickpea/field pea/lentil/wheat/paddy due to improved varieties under best-management practices (balanced nutrition including the bio fertilizers and crop protection). The yields of improved varieties further improved by 12-80% over the local variety, due to improved management that included balanced application of nutrients. This agrees with the suggestion of [49] even cereals under best production systems can perform to the maximum extent of 80 percent of potential productivity under real field conditions. The yield increase with the improved varieties under the farming situation of demonstration area is likely to be effective in area with similar micro climate.

Resource conservation through Modern irrigation methods

The modern irrigation methods *viz*. sprinklers and drip irrigation can play vital roles in improving water productivity. These irrigation systems are highly efficient in water application and have opened up opportunities to cultivate light textured soils with very low water-holding capacity and in irrigating undulating farm lands. The technology has also enabled regions facing limited water supplies to shift from low-value crops with high water requirements such as cereal to high value crops with moderate water requirements such as fruits, and vegetables

Application of review: Implementation of these improved irrigation techniques can be used to save water, energy and increase crop yields. However, currently the use of these improved irrigation methods is limited, primarily due to the high initial cost. Favourable government policies and the availability of credit are essential for popularizing these irrigation methods.

Review Category: Climatic Regime and Resource Management

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