Review Article

Agro-Techniques for Enhancing Wheat Productivity Under Dryland Conditions

Abstract

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Wheat, being a most important stable food crop of the world and second most important food crop after rice in India, played vital role in food securityof the country.Wheat is grownis growing inIndia in 6 wheat growing zones, both under irrigated and dry land conditions with a lot of variation in yield.Agronomic practices such as planting pattern, seeding rate, nitrogen (N) application strategy as well as cultivarsinfluencesinfluence the pattern of use of soil water (Fang et al., 2019).Despite sizeable area under dry land condition, production is very low mainly due to lack of proper adaptation of agro-technology. Although, there is sufficient scope to increase the dry land wheat productivity by treating seed with 1% Potassium salts, sowing drought tolerant varieties on or before 20th November in moist zone that gives more yield as compared to delayed sowing. Fertilizers application in the moist zone @ 50, 45 and 30 Kg N, P_2O_5, K_2O ha^{-1}, and one foliar application @ 2 % urea performed best under dry-land condition. Intercropping of dry land wheat with legume and oilseed (4:1) give more wheat equivalent yield over sole wheat.Weed management during (30-45 DAS) critical period of crop-weed competition increase wheat productivity.

Key words: Wheat, biofertilizers, rain-fed, dry-land, genotypes, intercropping

1. Introduction

Currently, rain-fed agriculture accounts for 55 per cent of the net sown area (139.42 M ha), and 61 per cent of India's farmer population and is therefore, crucial to the country's economy and food security. Presently, rain-fed agriculture accounts for around 40 per cent of the total food grain, 85% nutri-cereals, 83% pulses, 70% oilseeds and 65 % cotton production;

supports two-thirds of livestock and 40 percent of the human population (NRAA). Globally, wheat is the most important stable food crop, responsible for 41% of the total cereal calorie intake atas 35 and 74 % in developing and developed countries respectively (Shiferaw et al., 2013). However, in India it is second most important food crop after rice. As a rabi season crop, wheat played vital role in stabilizing the food grain production in the country. It is mostly eaten in the form of chapaties. Besides, wheat is also consumed in various other forms such as poories, dalia, halwa, sweet meals etc. In areas where rice is the staple food, wheat is used in the form of upma or poories. Wheat is also used for manufacturing of bread, flakes, cakes, biscuits etc. In India wheat is growing in 6 wheat growing zones throughout the country, both under irrigated and dry land conditions.However, there is a lot of variation in yield under both the condition, and these losses in wheat production are mainly due to abiotic factors including drought, salinity and heat stress rather than biotic factors (AbhinandanAbhiman et al., 2018).

In the recent past, recurrent drought events have threatened global wheat production; necessitates great attention. This yield reduction is mainly due to lack of proper adaptation of agro-technology. Despite sizeable area under dry land condition production is very low.Although, there is a sufficient scope to enhances the productivity of dry land areas. Significant variation for the genotypes over the years and environments may be attributed to changes over the years and /or in environments, which may affect drought hardening of plants leading to changes for grain yield and water relation parameters under study (Jones et al. 1989). Significant variation for genotypes indicated differential responses of genotypes over irrigated and drought stressed conditions, indicating considerable scope for selection of suitable genotypes under drought stress conditions. The genotypes C 306, NI 5439 and VL 421 performed better under drought stress conditions, while HPW 251, Hindi 62, Raj 3765 and VL 892 performed better under both irrigated and drought stress environments. Therefore, adoption of suitable cultivar and proper agro-technology is needed to increase the productivity through concerted effort of farmers under dry land conditions.

2. Demand of food grains

During 1980s the food production rate was 3.3%, but now a day it has declined to 1.8%, while our population is increasing as increasing rate by 1.8%. The present population of the country is 1.21 billion (2011) and it has been expected that will increase up to 1.4 billion by 2025 and up to 1.7 billion by 2050, needing food annually of about 380 and 480 million tons respectively. The dwindling cultivated land availability has decreased from 0.5 ha during 1950-51 to 0.15 ha up to 2001, and will further decrease to 0.05 ha by 2025. So, it has been clear~~cleared~~ that, there is no possibility in horizontal development of land, and increasing productivity/unit area is only the alternative. And therefore, increasing productivity/unit is only possible through the adaptation of proper agro-technology from given available resources. Hence, there is a need to give emphasis on marginal land in which dryland is of key importance.

3. Dry-lands and its constraints:

The most characteristics feature of dry land is evapotranspiration exceeds precipitation, high temperature, high wind velocity, more incidence of solar radiation, and low relative humidity. However, on the basis of annual rainfall received dry land agriculture is categorized into three categories-

1. **Dry farming** (Rain fall received <750 mm)
2. **Dry land farming** (Rain fall received between 750-1150 mm)
3. **Rain fed farming (**Rain fall received >1150 mm)

3.1 Constraints associated with wheat productivity under dry land condition

Theseconstants are categorized in four categories which are given below

3.1.1 Climatic

Low rain fall, high temperature, high wind velocity, and more incidence of solar radiation cause more evapotranspiration thereby reducing yield.

3.1.2 Edaphic

Marginal land having inadequate soil depth, low organic matter, low moisture retention capacity and high salt accumulation on soil surface affect the growth and development of plants~~plant~~ and reduces the yield.

3.1.3 Technological

Farming is mainly based on human and animal power based, hence, within short period of favourable weather condition entire area could not be covered and losses the chance of crop adaptation.

3.1.4 Socio-economicecomomic

Farmer in dry land areas' having poor economic status and low farm income, therefore, crop management is very poor and consequently that reduces the crop yield.

4. Possible strategies that can maintain crop productivity under dry land conditions

4.1 Seed hardening/priming:

Seed priming is increasingly considered a better approach to enhancing rapid and uniform emergence and to achieving high seedling vigor and better yields in vegetables, floriculture, and some field crops (Dearman et al., 1987; Parera and Cantliffe, 1994; Bruggink et al., 1999). In addition to better establishment, farmers have reportedthat primed crops grew more vigorousmore vigorously, flowered earlier, and gave higher yields (Farooq et al., 2008; Lemrasky and Hosseini, 2012).Common priming techniques include osmopriming (soaking seeds in osmotic solutions such as polyethylene glycol), halopriming (soaking seeds in salt solutions), hydropriming (soaking seeds in water), matripriming (placing seeds between saturated jute mat layers), and hardening (alternate soaking of seeds in tap water and drying before sowing) (McDonald, 2000; Basra et al., 2003).Priming of wheat seed in osmoticum or water may improve germination and emergence (Ashraf and Abu-Shakra, 1978) and promote vigorous root growth (Carceller and Soriano, 1972) under low soil water potential compared with checks. Osmotica that have shown good potential to enhance germination, emergence, growth, and/or grain yield of wheat by seed treatment with 1.0% solutions of potassium hydro phosphate (KH_2PO_4) monobasic made plant capable to withstand (Table.1) drought under dry land condition (Das and Choudhary, 1996).Seeds primed with PEG-6000, IAA (100ppm), and distilled water treatments, increased seed germination percentage, seedling emergence percentage, and seedling growth rate. PEG, KCl (2.5%), and hydropriming treatments increased grain yield compared to the control. Among the different priming agents used in the study, PEG, KCl, and hydropriming were the most effective treatments to attain higher germination percentage and grain yield (Toklu et al, 2015).

4.2 Sowing at right time:

Among the factorsinfluencing wheat productivity under dry-land condition, the sowing date is of particular importance. This inturn is closely correlated with soil preparation, which has a critical effect on seed germination, moisture and nutrient availability. Hussain *et al.*, (2012) reported that late sowing as one of the major causes for the low wheat productivity and they found that 58% yield was reduceds under late sown conditions as compared to normal sown wheat. Delay in sowing beyond November by each day causes a yield reduction of 5 kg/ha/day in North-Eastern parts of the country and 41.6 kg/ha/day in North-Western and Central parts of the country. For wheat crop sown in January after toria, sugarcane, potato, etc., thermo-insensitive short duration cultivars needs to be used. This time of sowing has least productivity in all wheat zones. Rain-fed wheat is sown early, from mid October to first quarter of November. Early sowing of winter wheat is likely to expose the crop not only to higher temperature, but also a critical day length for flowering (Musick and Dusek, 9801980). On the other hand late sowing of wheat and barley might expose the crop to higher temperature after and during heading, resulting in reduced number of ears and number of grains/ear (Randhawa *et al.*, 1977).Tomar *et al.* (1991) conducted an experiment at Udaipur and resulted that LAI and leaf area duration (LAD) decreased progressively with delay in sowing after 10^{th} December. Singh *et al.* (1995) also observed significant reduction in LAI with delay in wheat sowing from November to December. Tiwari *et al.* (1999) conducted field trials at Khandwa (MP) to investigate the impact of improved agro techniques on wheat, which was sown in second week of December and found that a seed rate of 125 kg/ha gave significantly higher grain and straw yield and number of effective tillers (m^{-2}) than higher and lower seed rate of this. Singh *et al.* (1999) found that 200 kg seed ha^{-1}produced significantly higher grain yield than 100 kg ha^{-1} and 150 kg $ha^{-1}$when the crop was sown on 29^{th} December at Samastipur (Bihar).Higher temperature during vegetative stage results inpoor tillering, growth and development (Choudhury and Wardlaw, 1978).The sowingSowingof seed on or before 20^{th} November (table 2) under dry land condition increases wheat yield significantly over late sowing beyond 20^{th} November (Sarker et al., 1992) at Jabalpur.

4.3 Drill sowing:

In rain-fed~~rainfed~~ areas, field preparation should be done with great care as conservation of moisture is dependent on it. The land is prepared by giving one deep ploughing with mould board plough followed by 2-3 ploughing and planking. In these areas, ploughing should be done in the evening time and furrows should be kept open whole night to absorb some moisture from dew. The planking should be done after each ploughing early in the morning. In recent times, with the development of seed drills, “zero tillage” sowings are practiced after rice especially. This practice not only economizes cost of land preparation, but also reduces weed menace owing to non-ploughing of the land. The existing weeds may be killed by non-selective herbicides (paraquat, glyphosate) spray.Singh *et al*. (2005) concluded from a field experiment in Uttar Pradesh, India, that in wheat, strip drilling resulted in higher growth and grain yield (5.67 t ha^{-1}), followed by zero tillage drilling, conventional sowing and bed planting. The broadcast sowing generally gave lower yields than sowing in rows (Krezel and Sobkowicz, 1996).

4.4 Drought tolerant varieties:

Drought affects every aspect of the plant growth and the ability to yield well under stress is conditioned by different physiomorphic traits. These traits are genetically complex and are not easy to manipulate. So, little success has been achieved to develop drought tolerant wheat varieties over the last 50 years. A number of physiological traits like leaf water potential, stomatal frequency, stomatal size, osmotic adjustments that are associated with drought resistance have been identified in wheat and are relatively simple in inheritance (Ahmad *et al*., 2000).

Moreover, selection and breeding for drought resistance in crops ~~has~~ havebeen considered to be an economical and efficient means of overcoming drought problem (Blum, 1983).Drought tolerant verities (Fig. 1) also play vital role in enhancing wheat productivity under dry land condition. In this experiment Sujata variety was grown which gave significantly higher yield over WH-147, HD-2189 and HD-2285 (C. M. Mishra 1993).

4.5 Bio-fertilizers

Bio-fertilizers also play an important role in increasing wheat productivity by mineralizing and solubilizing nutrients present in soils in the area of low and erratic rainfall where crop yields rely exclusively on rain water. Some plant growth promoting rhizobacteria (PGPR) capable of producing 1-aminocyclopropane-1-carboxylic acid (ACC) deaminase can mitigate the negative impact of water stress on plant in rain-fed agriculture through modulation of plant stress hormone ethylene.The rhizobacteria's ability to produce ACC deaminase is a very important mechanism to reduce ethylene level and promoting the growth of plants, especially the roots (Brunetti et al., 2021). Any decrease in ACC levels in roots of plants will lead to a reduction in ethylene concentration during stress. Regarding this, Sujata variety when sown on 20th October, where 50% RDF were applied and seed was treated~~treatment~~ with *Azospirillum*@5g/kg of seed,gave yield at par with RDF and RDF + seed treated with *Azospirillum.* Hence 50% chemical fertilizers is as good as 100%, and can be used~~use~~ as low cast input technology to enhances the productivity under dry land~~s~~ condition (Sawarkar*et al*., 1996).Bangash et al., (2013) reported that lateral roots were greater in the case of the inoculated plants with PGPR (isolated from rain-fed areas) than uninoculated control. Thus, PGPR isolated from rain-fed area can be used for biofertilizer formulation which could be very effective to increase the production of wheat in rain-fed agriculture system

4.6 Intercropping

Intercropping of wheat with legumes and oilseeds increased wheat equivalent yield significantly. An experiment was conducted at kullu regarding intercropping in which intercropping of wheat with brown sarson at the ratio of 4:1 gave significantly higher wheat equivalent yield over the sole wheat crop. Besides this wheat + linseed and wheat + lentil also gave higher wheat equivalent yield over the sole wheat crop (Nayital,~~Naital~~*et al.*, 1991). Similarly,Kaushik et al., (2016) reported thatintercropping of wheat + chickpea with at the row ratio of 2:2 was found to be suitable for higher production, wheat equivalent yield, land equivalent ratio, net return and B:C ratio.

4.7 Weed management:

Weed management also plays vital role in wheat productivity under dry land condition by reducing moisture and nutrient competition. Regarding this an experiment was conducted at Jorhat, in which weed free period up to 45 DAS gave yield at par with season long weed free period. While weedy plot up to 30 DAS also was not sufficient to make critical difference with season long weed free period. Which results the difference of 30 and 45 DAS is the critical period of weed competition. If farmer kept their field free from weeds during this period, yield can be enhanced (Gogoi et al 1993). In wheat, weeds are effectively controlled by two hand-weedings / hoeings, first one 25-30 DAS and the subsequent 40-50 DAS.

If the cultural methods is not possible due to any factor, then one can go as chemical application. Application of Pendimethaline @1.0 kg/ha gave higher yield overall~~over all~~ chemical followed by Fluroxypyr @0.2 kg/ha and Tralkozydim @0.4 kg /ha (Jat et al., 2004). If at least one irrigation is possible, for control of broad leaved weeds, spray of 2,4-D ethyl ester @ 0.4 kg a.i./ha in 700-800 litres of water at 35 days after sowing. Its spray earlier than this stage causes ear head malformation leading to uneven seed size. Monocot weeds can be effectively controlled by spraying of isoproturon @ 1.0 kg/ha or metoxuron or methabenzthiazuron @ 1.5 kg/ha at 30-35 DAS. Pre-emergence application of pendimethalin @ 1.0 kg/ha also provides broad-spectrum weed control.

Table. 1 Effect of seed hardening with potassium hydro phosphateon yield and yield attributes of rain-fed wheat (Das and Choudhary, 1996)

Treatments	Length of panicle (cm)	1000 grain weight (g)	Grain yield (q/ha)
Normal seed	9.5	43.0	18.1
Hardened seed	10.0	43.8	20.0
CD (P=0.05%)	0.3	0.4	1.4

Table. 2 Effect of sowing date and seed rate on yield and yield attributes of wheat under rain-fed condition

Treatments	Grain yield (q/ha)	No. of spikes m^{-2}	No. of grains per spike	Days to maturity
Sowing dates				
20 Nov.	17.95	153	31.6	90.0
5 Dec.	13.58	136	31.4	88.7
LSD 5%	1.39	1.3	2.0	NS
Seed rate (kg/ha)				
80	9.70	107	27.6	90.0

100	10.97	130	26.9	90.2
120	12.18	148	25.7	91.2
LSD 5%	0.51	0.7	NS	NS

Table 3. Response of planting methods on grain yield in wheat (Abbas *et al*., 2009)

Planting methods	**No. of grains spike^{-1}**	**Grain yield (kg ha^{-1})**
Broadcasting (control)	42.64	4367
Plaanting at 15 cm apart in rows	36.60	3792
Plaanting at 22.5 cm apart in rows	41.40	4283
Plaanting at 30 cm apart in rows	38.33	3725
LSD at 0.05%	1.28	175.3

Table 4. Response of rainfed wheat to method of sowing and fertilizer placement (Altab *et al*., 1992 at Gazipur)

Treatments	**Grain yield(q/ha)**	**Straw yield (q/ha)**
Broadcasting + broad cast fertilizers (Control)	11.4	24.0
Drilling + fertilizers broadcast	14.3	24.9
Broadcasting + fertilizers placed at 10 cm below depth	15.1	26.1
Drilling+fertilizers placed in same furrow in moist subsurface	26.5	36.1
Drill sowing + fertilizers placed in adjacent furrow	16.2	24.4
CD(P=0.05%)	4.2	6.8

Table 5. Effect of bio-fertilizer on grain yield of rain-fed wheat

Treatments	Grain yield (q/ha)
Control	10.74
N30, P8.73, K8.33	14.43
N30, P8.73, K0	11.31
RDF+Azospirillum	12.86

50% RDF+Azospirillum	12.59
CD (P=0.05%)	2.17

Table 6. Performance of wheat based intercropping under rainfed condition

Treatments	Grain yield (q/ha)	Intercrop (q/ha)	Wheat equivalent yield (q/ha)
Wheat	37.5	-	37.5
Wheat + brown sarson	37.0	2.9	48.4 (29%)
Wheat + linseed	37.6	1.9	41.6
Wheat + lentil	33.1	1.5	38.5
Wheat + pea	33.2	1.1	37.1
CD (P=0.05%)	NS	NS	6.7

Table7. Effect of weed management practices on rainfed wheat

Treatments	**Grain yield (qha^{-1})**
Weed free up to 30 DAS	21.50
Weed free up to 45 DAS	23.63
Weed free up to 60 DAS	24.60
Season long weed free (control)	25.43
Weedy up to 30 DAS	23.44
Weedy up to 45 DAS	21.63
Weedy u p to 60 DAS	20.08
CD (P= 0.05%)	2.7

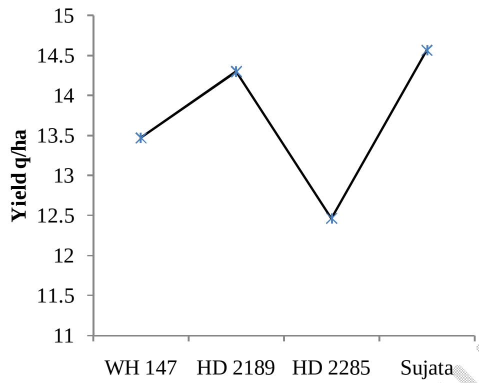

Figure 1 Response of wheat genotypes to yield under dry land conditions

Conclusion:

For achieving optimum plant stand farmer should treat the seed with 1% Potassium salts for hardening, adopt drought tolerant varieties like Sujata, C 306, NI 5439 and VL 421 etc. Drilling of seed on or before 20th November, in moist zone increase wheat yield. Fertilizer application in moist zone @ 50, 45 and 30 Kg N, P_2O_5, K_2O ha^{-1} and if possible one foliar application @ 2 % urea enhances the crop yield under dry-land condition. Intercropping of dry land wheat with legume and oilseed (2: 2 or 4:1) gives more wheat equivalent yield over sole wheat. Biofertilizers formulation will also be very effective to increase the production of wheat in rain-fed agriculture system.Weed management during critical period ((30-45 DAS) of crop-weed competition also increases wheat productivity under rain-fed areas.

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